

## Appendix 1

# Risk Evaluation of PCB Emissions from Liquid Waste Processing Facilities

In support of the “*Application for Risk-Based Disposal for Polychlorinated Biphenyls --  
Hanford 200 Area Liquid Waste Processing Facilities*”

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## TABLE OF CONTENTS

A.1.0	INTRODUCTION .....	A-5
A.2.0	PCB EMISSION MODEL .....	A-7
A.2.1	Approach.....	A-7
	A.2.1.1 Description of the Model for the Evaporator .....	A-7
	A.2.1.2 Description of the Model for ETF .....	A-10
A.2.2	Summary Calculation Spreadsheets.....	A-19
A.2.3	Sample Calculation of Emission Rate.....	A-31
A.3.0	RISK EVALUATION MODEL FOR PCB.....	A-33
A.3.1	Description of Model .....	A-33
A.3.2	Air Dispersion Model for the Evaporator and the ETF .....	A-33
A.3.3	Toxicity Evaluation.....	A-36
A.3.4	Model Results for Exposure Concentrations .....	A-37
A.3.5	Human Risk Characterization .....	A-41
A.3.6	Ecological Risk Characterization.....	A-46
A.3.7	Uncertainty Analysis.....	A-50

### Tables

Table A.2-1	Decontamination Factors for ETF Units.....	A-14
Table A.3-1	Stack Characteristics.....	A-34
Table A.3-2	ISC3 Concentration Factors for Unit Release Rates.....	A-35
Table A.3-3	ISC3 Model Results for the Evaporator.....	A-38
Table A.3-4	ISC3 Model Results for ETF Configuration 1 .....	A-39
Table A.3-5	ISC3 Model Results for ETF Configuration 3 .....	A-40
Table A.3-6	Human Risk Calculations for the Evaporator .....	A-42
Table A.3-7	Human Risk Calculations for the ETF Configuration 1 .....	A-43
Table A.3-8	Human Risk Calculations for the ETF Configuration 3 .....	A-44
Table A.3-9	Combined Evaporator and the ETF (Configuration 3) .....	A-46
Table A.3-10	Dose or Concentration to Ecological Receptors at 0.2 µg/L PCB in Wastewater Received by LWPF .....	A-47
Table A.3-11	Dose or Concentration to Ecological Receptors at 600 µg/L PCB in Wastewater Received by LWPF .....	A-48
Table A.3-12	Dose or Concentration to Ecological Receptors at 6000 µg/L PCB in Wastewater Received by LWPF .....	A-49

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## A.1.0 INTRODUCTION

This appendix provides detailed information to support the risk evaluation conclusions contained in Sections 3.3.1 and 3.2.2 of the parent document, “*Application for Risk-Based Disposal Approval for Polychlorinated Biphenyls -- Hanford Site Liquid Waste Processing Facilities*” (Application). This appendix pertains only to the evaluation of risk for exposure to polychlorinated biphenyls (PCB) via the air pathway from the Evaporator (Evaporator) and the 200 Area Effluent Treatment Facility (ETF). Emission of PCBs from the 200 Area Liquid Effluent Retention Facility is considered negligible, as discussed in Section 2.2, and therefore is not included in the risk evaluation.

Acronyms used in this appendix are defined in the Acronym List in the Application. References cited in this appendix are included in Section 7.0 of the Application.

The first step in the risk evaluation is the calculation of the amount of PCB emissions to the air pathway from the operation of the Evaporator and the ETF. The calculated emissions are based on three different PCB concentrations in the aqueous wastestreams received by the Evaporator and the ETF (0.2 µg/L, 600 µg/L, and 6,000 µg/L). The rationale for selection of these concentrations is provided in Section 3.1.1 of the Application. Two scenarios were run for the ETF, based on two different operation configurations. The combined risk from the Evaporator and the ETF is based on the more conservative configuration of the ETF processing equipment (Configuration 3), as explained in Section 3.1.1 of the Application. The method of calculating PCB emissions from the Evaporator and the ETF is described in Section A.2.0, below.

The next step in the risk evaluation is modeling the air dispersion of PCBs as they are emitted from the Liquid Waste Processing Facilities (LWPF) and travel to various points of receptor exposure (i.e., Hanford Site workers, the public, and ecological receptors). This step is followed by calculating the exposure of each receptor to PCBs. Finally, the risk from exposure for PCBs is calculated for each receptor. The risk evaluation model is described in Section A.3.0, below, and is summarized in Sections 3.2.1 and 3.2.2 of the Application.

The *Framework Agreement for Management of Polychlorinated Biphenyls (PCBs) in Hanford Tank Waste*, (Boston et. al. 2000) requires that authority to manage PCB remediation waste in Hanford Site tank farms and associated facilities be obtained via an application for Risk-Based Disposal Approval (RBDA), under the Toxic Substances Control Act (TSCA). The ORP will submit its RBDA application to the EPA, supported by the specific risk assessment information contained in *Double-Shell Tank System PCB Risk Assessment* (CHG 2001a).

The LWPF units are associated with the tank farms, as they receive tank waste supernatant for evaporation to reduce the tank waste volume and for further treatment of the process condensate to destroy or remove PCBs. The Application for the LPWF to

receive higher concentrations of PCBs (i.e., greater than 0.5 µg/L) parallels the PCB risk assessment prepared for the tank farms, to the extent practicable. The assumptions contained in the tank farm risk assessment also apply to the Application and this appendix, unless otherwise stated. This provides the best opportunity for comparison of the results from one risk evaluation to the other.

## A.2.0 PCB EMISSION MODEL

The PCB emissions for the Evaporator are modeled in the same way they were modeled for the “*Toxic Substances Control Act Risk Evaluation of the Evaporator for the Evaporator Campaign 2001-01*” (FH 2001a). The descriptions of these models are shown below.

### A.2.1 Approach

This section contains a description of the model used to calculate PCB air emissions from the Evaporator and the ETF.

#### A.2.1.1 Description of the Model for the Evaporator

The Evaporator is modeled as five partition units:

- CA-1 Vapor Liquid Separator (Evaporator Vessel)
- EC-1 Primary Condenser
- EC-2 Intercondenser
- EC-3 Aftercondenser
- C-100 Condensate Collection Tank.

The first four units are modeled as ideal equilibrium units, where Henry's Law is used to determine the equilibrium between the exiting liquid and gas phases. The condensate collection tank, C-100, is modeled differently than the other units because there is little mixing of the vapor and liquid phases. It is modeled using a two-phase mass transfer formula.

#### **DETERMINE PCB FRACTIONATION IN THE EVAPORATOR VESSEL AND CONDENSERS**

The Evaporator vessel and the three condensers are modeled assuming the vapor in each unit is in equilibrium with the solution, because processing in these units involves thorough mixing of the vapor and liquid phases. Equilibrium can be determined for dilute aqueous solutions using Henry's Law:

$$y_A P = x_A H_A \quad \text{or} \quad y_A = x_A \left( \frac{H_A}{P} \right) \quad (1)$$

where:

$y_A$  = mole fraction of component A in the vapor phase

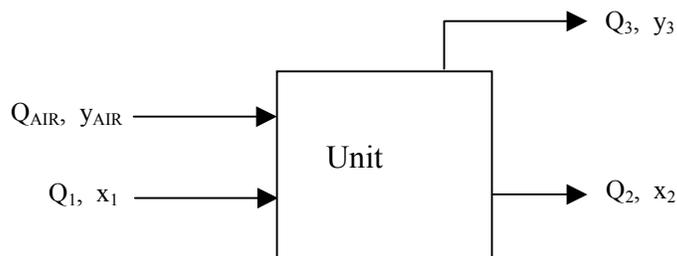
$x_A$  = mole fraction of component A in the liquid phase

$H_A$  = Henry's Law constant for component A.

P = System pressure

Henry's Law constants are temperature dependant, increasing with rising temperature, and some documents provide temperature correction factors (Sander 1999). Given Evaporator flowrates, operating temperatures and pressures, the partitioning of PCBs through the evaporator vessel and condensers can be determined.

A typical material balance is:



where:

$Q_{AIR}$  = Moles of air entering the vessel (air leak or air inbleed)

$y_{AIR}$  = Mole fraction of PCBs in air entering the vessel (= 0)

$Q_1$  = Moles of waste solution entering the vessel

$x_1$  = Mole fraction of PCBs in waste solution entering the vessel

$Q_2$  = Moles of waste solution leaving the vessel

$x_2$  = Mole fraction of PCBs in waste solution leaving the vessel

$Q_3$  = Moles of vapor leaving the vessel through the vent system

$y_3$  = Mole fraction of PCBs in vapor leaving the vessel through the vent system

The molar PCB balance is ( $y_{AIR} = 0$ ):

$$x_1 Q_1 = x_2 Q_2 + y_3 Q_3 \quad (2)$$

Rearranging the Henry's Law's law (equation 1):

$$x_2 = y_3 \left( \frac{P}{H_{PCB}} \right) \quad (3)$$

Substituting Equation 3 into Equation 2 yields:

$$x_1 Q_1 = y_3 \left( \frac{P}{H_{PCB}} \right) Q_2 + y_3 Q_3 \quad \text{or} \quad x_1 Q_1 = y_3 \left[ \left( \frac{P}{H_{PCB}} \right) Q_2 + Q_3 \right] \quad (4)$$

Solving for  $y_3$ :

$$y_3 = x_1 Q_1 / \left[ \left( \frac{P}{H_{\text{PCB}}} \right) Q_2 + Q_3 \right] \quad (5)$$

Because the quantities of volatile constituents, such as PCBs and other organics, are small compared to the total flow,  $Q_1$ ,  $Q_2$ , and  $Q_3$  can be readily determined by the material balance of air and water. The steps in the attached modeling calculations involve determining the molar flowrates by performing a material balance for air and water for each unit and calculating  $x$  and  $y$  for each unit using the molar flowrates and Equations 3 and 5.

The primary variables in the equilibrium calculations above are the operating pressure and the Henry's Law constant. The operating pressures for the various units were taken from technical information, such as campaign operating data and jet pump performance curves. The Henry's Law constants were taken from the Army Corps of Engineers (U.S. Army COE 1997) and from Rolf Sander of the Max Planck Institute of Chemistry (Sander 1999). The Sander data is particularly useful because it provides temperature correction factors that are needed to model the elevated temperatures.

#### **DETERMINE THE PCB FRACTIONATION IN THE CONDENSATE COLLECTION TANK**

The condensate collection tank, C-100, is modeled differently than the other units because there is little mixing of the vapor and liquid phases. The tank contents are not agitated (although the tank is equipped with an agitator) and condensate from the condensers enters the bottom of the tank through dip legs, leaving the surface undisturbed. The emissions from C-100 are modeled using a two-phase mass transfer calculation:

$$J_A = K_A \left( c_A - \frac{c_{\text{Air}}}{H_A} \right) \quad (6)$$

where:

$J_A$  = flux of component A to the vapor phase, gm/cm<sup>2</sup>-sec

$K_A$  = overall mass transfer coefficient of component A, cm/sec

$c_A$  = liquid phase concentration of component A, gm/cm<sup>3</sup>

$c_{\text{Air}}$  = air phase concentration of component A, gm/cm<sup>3</sup>

$H_A$  = Henry's Law constant, dimensionless version

The quantity of PCBs volatilized can be determined by multiplying the flux,  $J_A$ , by the contact area between the liquid and gas phases; in this case, the surface area of the liquid in tank C-100. In most cases, including the PCB model below, the concentration of the constituent in the air is much lower than the concentration in the liquid, so the equation becomes:

$$J_{\text{PCB}} = K_{\text{PCB}} c_{\text{PCB}} \quad (7)$$

The overall mass transfer rate,  $K$ , is given by the equation:

$$\frac{1}{K_{\text{PCB}}} = \frac{1}{k_1} + \frac{1}{k_g H_A} \quad \text{or} \quad K = \frac{k_1 k_g}{k_g + \frac{k_1}{H_A}} \quad (8)$$

where:

$k_1$  = mass transfer rate of PCBs in liquid phase, cm/sec

$k_g$  = mass transfer rate of PCBs in gas phase, cm/sec

The mass transfer rate in the gas phase,  $k_g$ , is set equal to the convection flow in the vapor phase, which is calculated as the tank off-gas flowrate divided by the surface area. The mass transfer rate in the liquid phase,  $k_1$ , is determined by equations given in *PCBs in the Upper Hudson River: Volume 2: A Model of PCB Fate, Transport, and Bioaccumulation* (General Electric 1999). The value for  $k_1$  depends on the depth and velocity of the liquid, and the diffusivity of PCBs in the liquid. The diffusivity in turn depends on the viscosity of the liquid. As it turns out in the model, the value of  $k_g$  is much greater than  $k_1$ , so (from Equation 8)  $K$  approximately equals  $k_1$ . This indicates the mass transfer rate through the liquid phase is the limiting factor for emission from diffusion.

The C-100 tank is equipped with a set of three air bubblers used to measure liquid levels in the tank. Emissions from the bubblers are modeled using the method described above, and are added to the emission from the two-phase mass transfer.

### **MODELING RESULTS**

The model shows the high temperature and vacuum in the evaporator vessel, CA-1, results in more than 99 percent of the PCBs volatilizing and entering the condenser system. The primary condenser, EC-1, operates at a lower temperature, causing about 93 percent of the PCBs to condense with the water vapor and enter the process condensate which transfers to the LERF. The remaining 6.5 percent of the PCBs emit from the Evaporator vessel vent system to the air, because the remaining two condensers operate at higher temperatures (their primary function is to condense steam used by the steam jet pumps). About 0.25 percent of the PCBs in the process condensate emit from the unagitated C-100 tank. Altogether, about 6.7 percent of the PCBs are emitted to the atmosphere, with the remaining PCBs going to the LERF.

#### **A.2.1.2 Description of the Model for ETF**

The ETF can be operated in various configurations depending on the nature of the feed material and the required treatment. To allow for modeling of different unit arrangements, a decontamination factor was developed for each unit:

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$$\text{Decontamination Factor (DF)} = \frac{\text{molar rate of component in feed entering unit}}{\text{molar rate of component in liquid exiting unit}}$$

The DFs for most units are based on the assumption that the liquid and gas streams exiting each unit are in equilibrium. The DFs for the ultraviolet/oxidation (UV/OX) unit and the Degasification Column do not involve simple equilibrium. The UV/OX destroys organic material, so its DF does not include an air emission. The Degasification Column uses countercurrent airflow which involves multiple equilibrium stages. The following text describes how the DF is calculated for equilibrium units (tanks, evaporator, dryer, etc.), how the DF for the UV/OX unit was determined, and how the DF for the Degasification Column was determined.

#### **DETERMINE PCB FRACTIONATION IN THE UNITS AT ETF**

Each unit at ETF that is vented (except the Degasification Column) is modeled assuming the vapor in the unit is in equilibrium with the solution. Equilibrium can be determined for dilute aqueous solutions using Henry's Law:

$$y_A P = x_A H_A \quad \text{or} \quad y_A = x_A \left( \frac{H_A}{P} \right) \quad (1)$$

where:

$y_A$  = mole fraction of component A in the vapor phase

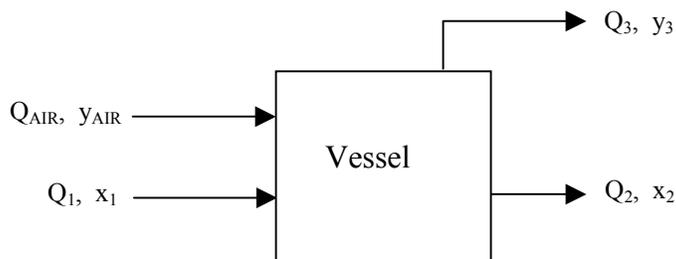
$x_A$  = mole fraction of component A in the liquid phase

$H_A$  = Henry's Law constant for component A.

$P$  = System pressure

Henry's Law constants are temperature dependant, increasing with rising temperature, and some documents provide temperature correction factors (Sander 1999). Given ETF flowrates, operating temperatures and pressures, the DF of PCBs through the vessels can be determined.

A typical material balance is:



where:

$Q_{AIR}$  = Moles of air entering the vessel

$y_{AIR}$  = Mole fraction of PCBs in air entering the vessel (= 0)

$Q_1$  = Moles of waste solution entering the vessel

$x_1$  = Mole fraction of PCBs waste solution entering the vessel

$Q_2$  = Moles of waste solution leaving the vessel

$x_2$  = Mole fraction of PCBs in waste solution leaving the vessel

$Q_3$  = Moles of vapor leaving the vessel through the vent system

$y_3$  = Mole fraction of PCBs in vapor leaving the vessel through the vent system

The material balance equation is:

$$x_1 Q_1 + y_{AIR} Q_{AIR} = x_2 Q_2 + y_3 Q_3 \quad (2)$$

Since the molar flowrate of PCBs in the air inleakage is zero ( $y_{AIR} = 0$ ), the equation becomes:

$$x_1 Q_1 = x_2 Q_2 + y_3 Q_3 \quad (3)$$

Rearranging the Henry's Law (Equation 1):

$$y_3 = x_2 \left( \frac{H_{PCB}}{P} \right) \quad (4)$$

Substituting for  $y_3$  in Equation 3:

$$x_1 Q_1 = x_2 Q_2 + x_2 \left( \frac{H_{PCB}}{P} \right) Q_3 \quad (5)$$

Dividing both sides by  $x_2 Q_2$  yields the decontamination factor for the unit ( $DF = x_1 Q_1 / x_2 Q_2$ ):

$$DF = \frac{x_1 Q_1}{x_2 Q_2} = 1 + \left( \frac{H_{\text{PCB}}}{P} \right) \frac{Q_3}{Q_2} \quad (6)$$

The molar flowrate in the liquid can be defined in terms of the DF:

$$x_2 Q_2 = \frac{x_1 Q_1}{DF} \quad (7)$$

The molar flowrate in the vapor phase can also be described in terms of the DF. Substituting the value for  $x_2 Q_2$  in Equation 7 into Equation 3:

$$x_1 Q_1 = \frac{x_1 Q_1}{DF} + y_3 Q_3 \quad \text{or} \quad x_1 Q_1 - \frac{x_1 Q_1}{DF} = y_3 Q_3 \quad \text{or} \quad x_1 Q_1 \left[ 1 - \frac{1}{DF} \right] = y_3 Q_3 \quad (8)$$

$$y_3 Q_3 = x_1 Q_1 \left[ 1 - \frac{1}{DF} \right] \quad (9)$$

Note that in Equation 6, as the Henry's Law constant increases, or the vapor airflow increases, the DF goes up - and the quantity emitted also goes up (Equation 9). Because the quantities of volatile constituents is small compared to the total flow,  $Q_1$ ,  $Q_2$ , and  $Q_3$  can be readily determined by the material balance of air and water. The model determines the DF for each tank given the operating temperature, operating pressure, vent airflow, and liquid flow exiting the vessel. The temperature is used to determine the value of Henry's Law constant. Once the DFs are determined, Equations 7 and 9 can be used to calculate the molar flowrate in each stream exiting the vessel.

#### Determining DF for ETF Units

To determine the DF for each unit, the operating temperature, operating pressure, vent airflow, and liquid flow exiting the vessel are needed. The Henry's Law constants were taken from the Army Corps of Engineers (U.S. Army COE 1997) and from Rolf Sander of the Max Planck Institute of Chemistry (Sander 1999). The Sander data is particularly useful because it provides temperature correction factors that are needed to model the elevated temperatures.

The Notice of Construction for ETF (DOE 1993a) gives airflows for the Surge Tank, Secondary Waste Receiving Tanks (SWRTs), and the Concentrate Tanks. All tanks operate at essentially atmospheric pressure (only a few inches water vacuum). The evaporator vessel operates at 18 in. water positive pressure. Because the Evaporator is under positive pressure, the inleakage is assumed to be very small.

The temperatures of some tanks vary considerably depending on plant and environmental conditions. The Surge Tank is located outside, with the maximum temperature being

somewhat below ambient summer temperatures. A value of 30°C was used, although the temperature would be considerably lower in the winter. The Concentrate Tank temperatures vary depending on whether they are receiving waste from the evaporator. A typical value of 60°C was used.

Summary Table of DF for Units at ETF

Table A.2-1 gives typical DFs for ETF equilibrium units. The tanks in the Primary Treatment Train emit about 3 percent of the PCBs entering them. The emission percentages are higher in the tanks of the Secondary Treatment Train because they operate at higher temperatures. Almost all the PCBs entering the Evaporator are volatilized, but most are recondensed in the cooler and are recycled to the Surge Tank. The same is true for the Thin-Film Dryer (TFD); however, the DF in the dryer is not particularly important because almost all the PCBs are removed by the ETF evaporator before the waste enters the dryer.

Unit	Average DF	% Emitted	Comment
Surge Tank	1.03	3.0	Unit is vented to VOG
pH Adjust Tank	1.03	3.0	Unit is vented to VOG
1st RO Tank	1.02	2.2	Unit is vented to VOG
2nd RO Tank	1.03	2.5	Unit is vented to VOG
SWRT Tanks	1.06	5.8	Unit is vented to VOG
Evaporator	1.4E+05	99.996	Unit is vented to evap cooler
Evap Cooler	1.001	0.074	Unit is vented to VOG
Concentrate Tanks	1.3	21	Unit is vented to VOG
TFD	8.2E+05	99.999	Unit is vented to spray condenser
TFD Spray Cond.	4.2	68	Unit is vented to VOG
RO: reverse osmosis SWRT: secondary waste receiving tank TFD: thin film dryer VOG: vessel off-gas			

**Table A.2-1 Decontamination Factors for ETF Units**

The DFs for the Reverse Osmosis System, 2nd pH Adjust Tank, and the Verification Tanks were not calculated because the PCB concentrations in these systems are miniscule. After the UV/OX system and the Degasification Column, it is assumed all remaining PCBs are discharged into the vent system *and* discharged to the soil.

**DETERMINE PCB FRACTIONATION ACROSS THE ULTRAVIOLET/ OXIDATION SYTEM**

The ETF process has an ultraviolet/oxidation process to destroy organics. The process was designed based on pilot plant and bench scale information. The results of pilot plant tests performed specifically for ETF organic constituents are given in the *200 Area ETF Delisting Petition* (DOE 1993b). This document served as the basis for EPA delisting of the ETF Verification Tank wastewater.

**Determine DF from Delisting Petition**

The Delisting Petition (DOE 1993b) models the UV/OX system at ETF as a first order kinetic reaction. The standard equation for first order reactions is:

$$C_A = C_{A0} e^{-kt} \quad (10)$$

where:

$C_A$  = concentration at time  $t$ , mol/L

$C_{A0}$  = initial concentration (time = 0), mol/L

$k$  = first order rate constant,  $\text{min}^{-1}$

$t$  = residence time in the reactor, min

Equation 10 can be rearranged to get a DF (i.e., the ratio of the feed concentration to the product concentrations):

$$DF = \frac{C_{A0}}{C_A} = \frac{1}{e^{-kt}} = e^{kt} \quad (11)$$

The residence time in the reactor is specific to the ETF design, while the reaction rate constant,  $k$ , is specific for each chemical constituent. The UV/OX system at ETF employs four units operating in parallel. The residence time, given in the Delisting Petition, is 2.08 minutes, based on a flowrate of 172 gal/min flowing through all four units, with six UV lamps operating per unit.

The value for the reaction constant,  $k$ , was taken from the UV/OX system manufacturers database. The manufacturer, Peroxide Systems, Inc. (now Calgon Corporation), gives a value of PCBs of 4.5 ( $\text{min}^{-1}$ ) in Appendix A of the Delisting Petition. The manufacturer includes notes that say, "rates [are] taken from pilot-scale or bench-scale testing data or full-scale operating data," and "rates obtained in low level total organic carbon and total dissolved solids water [are] adjusted by multiplying by 0.5 to get rates for worst case at Hanford."

The DF for the UV/OX system can be determined using Equation 11:

$$DF = e^{kt} = e^{(4.5)(2.08)} = 11,615 \quad (12)$$

A decontamination factor of 11,600 can be expected for the PCBs in the UV/OX system based on the information in the Delisting Petition. The PCBs decontaminated from the UV/OX system are destroyed with no vent emissions.

#### **DETERMINE PCB FRACTIONATION ACROSS THE DEGASIFICATION COLUMN**

The Degasification Column was designed to strip carbon dioxide from the waste by passing it down a packed column while an air stream is blown up the column. The degasification calculations are based on the formula for overall height of a transfer unit (HTU):

$$Z = N_{OLi} H_{Li} \quad (13)$$

where:

Z = height of the column, ft

$N_{OLi}$  = number of overall transfer units for species i, dimensionless

$H_{Li}$  = height of a transfer unit for species i, ft

The value for  $N_{OLi}$  is determined by the concentration in the feed and the desired concentration in the product. Design documentation (Adtechs) gives the following simplified equation:

$$N_{OLi} = \ln \left[ \frac{\text{conc. of species i, inlet}}{\text{conc. of species i, outlet}} \right] \quad (14)$$

Note that the ratio of concentrations in the inlet and outlet is the DF for the column.

The value of  $H_{Li}$  is specific to the design of the column, accounting for flowrates, packing design, etc. The Degasification Column was designed for the removal of carbon dioxide from the wastewater. The values for  $N_{OLi}$  and  $H_{Li}$  for carbon dioxide were determined to be 5.3 and 0.89 ft, respectively (Adtechs). A correction factor, provided by Adtechs, converts  $H_{Li}$  to 0.95 ft. The minimum column height is  $5.3 \times 0.95 = 5.0$  ft. The Degasification Column was conservatively designed to be 9 ft tall.

To determine the emission of PCBs, the number of transfer units,  $N_{OL}$ , is determined by dividing the height of the Degasification Column, after applying the correction factor, by the height of a transfer unit for PCBs,  $H_L$ . The height of a transfer unit is estimated based on available data for chlorobenzene.

#### **Determine the theoretical height of the Degasification Column**

The Degasification Column is 9 ft tall, but this height uses a correction factor to account for inefficiency in column performance (Adtechs).

$$Z^o = N_{OLi} H_{Li} \left(\frac{Z}{3}\right)^{0.15} \quad (15)$$

where:

$Z^o$  = actual height of the column, ft

Dividing Equation 15 by Equation 13 yields:

$$\frac{Z^o}{Z} = \left(\frac{Z}{3}\right)^{0.15} \quad (16)$$

for the Degasification Column,  $Z^o = 9$  ft. Solving for  $Z$  by iteration, we get  $Z = 7.8$  ft. Thus, although the column is 9 ft tall, its theoretical height is 7.8 ft, accounting for inefficiency in column performance.

Determine the height of a transfer unit

The height of a transfer unit depends on the Schmidt number,  $N_{SC}$ , a dimensionless number equal to the viscosity divided by the product of the density and diffusivity of the compound. Adtechs provides a graph of the water flux versus the  $H_L$ /sq.root of  $N_{SC}$ . This graph is specific to the model of Degasification Column at ETF and accounts for the column characteristics (i.e., width of column, type of packing, etc.). For the water flux at ETF (12,450 lbs/hr/ft<sup>2</sup>), the value is

$$\frac{H_L}{\sqrt{N_{SCL}}} = 0.045 \quad (17)$$

where:

$H_L$  = height of a transfer unit for the liquid phase, ft

$N_{SCL}$  = Schmidt number for the liquid phase, dimensionless

The height of the transfer unit for PCBs can be determined if the Schmidt number is known for PCBs at the conditions in the Degasification Column. Adtechs gives a graph of the square root of the liquid-phase Schmidt numbers versus temperature for oxygen and carbon dioxide. At 30°C (86°F), the square root values for carbon dioxide and oxygen are 19 and 16.5, respectively. The Schmidt numbers are then 19<sup>2</sup> and 16.5<sup>2</sup>, or 361 and 272, respectively.

*Unit Operations of Chemical Engineering* (McCabe et.al. 1976), Appendix 19, provides gas-phase Schmidt numbers for several compounds, including carbon dioxide (0.96), oxygen (0.74), and chlorobenzene (2.13). The chlorobenzene value will be used to represent PCBs. These numbers are for the gas phase; we will assume that the *ratio* of

compounds in the liquid phase will be the same as the gas phase. The ratio of gas phase Schmidt values for carbon dioxide-to-oxygen given by McCabe et.al. is  $0.96 / 0.74 = 1.30$ . The ratio of liquid phase Schmidt values for carbon dioxide-to-oxygen given by Adtechs is  $361 / 272 = 1.33$ . These similar values indicate the ratio method is a reasonable assumption.

The ratio of Schmidt numbers given by McCabe et.al. for chlorobenzene-to-carbon dioxide is  $2.13 / 0.96 = 2.22$ . The liquid-phase Schmidt number for chlorobenzene, using the same ratio, is  $2.22 \times 361 = 801$ . Equation 17 can be rearranged:

$$H_{Li} = 0.045\sqrt{S_{SCL}} \quad (17)$$

The height of a transfer unit for PCBs is therefore:

$$H_L = 0.045\sqrt{801} = 1.27 \text{ ft} \quad (18)$$

Determine the number of transfer units and decontamination factor

The number of transfer units for PCBs,  $N_{OL}$ , is the height of the column divided by the height of a transfer unit:

$$N_{OL} = Z / H_{Li} = 7.8 \text{ ft} / 1.27 \text{ ft} = 6.14 \quad (19)$$

Equation 14 can be used to determine the decontamination factor:

$$N_{OLi} = \ln \left[ \frac{\text{conc. of species } i, \text{ inlet}}{\text{conc. of species } i, \text{ outlet}} \right] = \ln[\text{DF}]$$

Solving for the case for PCBs:

$$N_{OL} = 6.14 = \ln[\text{DF}], \quad \text{or} \quad \text{DF} = \exp[6.14] = 460 \approx 500 \quad (20)$$

A decontamination factor of 500 can be expected for the PCBs in the Degasification Column. The PCBs decontaminated from the Degasification Column enter the vessel off-gas system.

### **MODELING RESULTS**

Two ETF configurations were modeled: Configuration 1 is the standard configuration where the waste from LERF enters the Surge Tank and is pumped through the Main Treatment Train. The Main Treatment Train includes the UV/OX, pH adjustment, degasification, reverse osmosis, and ion exchange units arranged in series.

Approximately three percent of the PCBs are emitted by the Surge Tank and about 97 percent of the PCBs are destroyed in the UV/OX unit. The remaining trace quantities of PCBs are vented because of the high DF in the Degasification Column. The PCB concentrations in the wastewater downstream of the Degasification Column are so low that further modeling is not needed. Only 0.000016 percent of the PCBs are discharged to the soil at the State Approved Land Disposal Site (SALDS).

Configuration 3 handles waste with concentrations of dissolved ionic species too high to be properly treated by reverse osmosis. Configuration 3 has two phases: in the first phase, the waste is transferred from LERF to the Secondary Waste Receiver Tanks (SWRTs) in the Secondary Treatment Train, where it enters the Evaporator and Thin Film Dryer. The boiloff from these units is transferred to the Surge Tank and either processed through the Main Treatment Train or sent back to the LERF for storage until later treatment through the ETF. The model shows the PCBs enter the Evaporator boiloff and return to LERF, with about 15 percent of the PCBs emitted from the SWRTs and Surge Tank. The percentage of PCBs emitted from the tanks in Configuration 3 is higher than in Configuration 1 because the liquid volumetric flowrates are smaller. In Equation 6, the value of  $Q_2$  is smaller, while the airflow,  $Q_3$ , is unchanged.

In the second phase of Configuration 3, the waste from the first phase is transferred through the Main Treatment Train in the same manner as Configuration 1. About three percent of the remaining PCBs are emitted and 97 percent destroyed. A time-weighted average emission was determined assuming the majority of the operating time will be in the phase 1 (because of its lower flowrates). In the weighted average, about 10 percent of PCBs are vented and 90 percent are destroyed. Only 0.000007 percent are discharged to SALDS.

### **A.2.2 Summary Calculation Spreadsheets**

The spreadsheets on the following pages in this section present the summarized calculations for PCB air emissions from the Evaporator and the ETF. Each treatment scenario is evaluated separately, based on concentration of PCBs in the wastestream received by the Evaporator, the ETF (Configuration 1), and the ETF (Configuration 2). Emissions are calculated for incoming aqueous waste at concentrations of 0.2  $\mu\text{g/L}$ , 600  $\mu\text{g/L}$ , and 6,000  $\mu\text{g/L}$ .

**The Evaporator Overall Partition Results for PCBs  
at 0.2 µg/L PCB Aqueous Waste Feed**

Constituent	CA-1 Feed g/min	CA-1 Overheads g/min	CA-1 Slurry g/min	CA-1 Overheads %	EC-1/2/3 Overheads g/min	EC-1/2/3 Condensate g/min	EC-1/2/3 Overheads %	Process Condensate g/min	C-100 Overheads g/min	C-100 Overheads %	Vessel Vent g/sec
Aroclor 1016	4.5E-05	4.5E-05	7.4E-09	99.98	3.0E-06	4.2E-05	6.6	4.2E-05	1.0E-07	0.25	5.1E-08
Aroclor 1221	4.5E-05	4.5E-05	1.3E-08	99.97	1.8E-06	4.4E-05	3.9	4.4E-05	8.7E-08	0.20	3.1E-08
Aroclor 1242	4.5E-05	4.5E-05	5.7E-09	99.99	3.8E-06	4.2E-05	8.3	4.2E-05	1.2E-07	0.28	6.5E-08
Aroclor 1248	4.5E-05	4.5E-05	5.5E-09	99.99	3.9E-06	4.1E-05	8.7	4.1E-05	1.2E-07	0.29	6.8E-08
Aroclor 1232	4.5E-05	4.5E-05	2.2E-07	99.52	2.3E-08	4.5E-05	0.05	4.5E-05	6.1E-08	0.13	1.4E-09
Aroclor 1254	4.5E-05	4.5E-05	5.3E-09	99.99	4.1E-06	4.1E-05	9.1	4.1E-05	1.2E-07	0.29	7.1E-08
Aroclor 1260	4.5E-05	4.5E-05	5.3E-09	99.99	4.1E-06	4.1E-05	9.1	4.1E-05	1.2E-07	0.29	7.1E-08
Averages	4.5E-05	4.5E-05	3.7E-08	99.92	3.0E-06	4.2E-05	6.5	4.2E-05	1.0E-07	0.25	5.1E-08

Constituent	CA-1 Slurry %	TK-C100 Condensate %	Vessel Vent %	Feed Conc µg/L	Slurry Conc µg/L	Process Condensate µg/L	VVent Conc µg/m3
Aroclor 1016	0.02	93.2	6.8	0.20	1.7E-04	0.22	0.20
Aroclor 1221	0.03	95.9	4.1	0.20	3.0E-04	0.23	0.12
Aroclor 1242	0.01	91.5	8.5	0.20	1.3E-04	0.22	0.25
Aroclor 1248	0.01	91.0	8.9	0.20	1.3E-04	0.21	0.26
Aroclor 1232	0.48	99.3	0.18	0.20	5.0E-03	0.23	0.005
Aroclor 1254	0.01	90.7	9.3	0.20	1.2E-04	0.21	0.27
Aroclor 1260	0.01	90.7	9.3	0.20	1.2E-04	0.21	0.27
Averages	0.08	93.2	6.7	0.20	8.5E-04	0.22	0.20

**The Evaporator Overall Partition Results for PCBs  
at 600 µg/L PCB Aqueous Waste Feed**

Constituent	CA-1 Feed g/min	CA-1 Overheads g/min	CA-1 Slurry g/min	CA-1 Overheads %	EC-1/2/3 Overheads g/min	EC-1/2/3 Condensate g/min	EC-1/2/3 Overheads %	Process Condensate g/min	C-100 Overheads g/min	C-100 Overheads %	Vessel Vent g/sec
Aroclor 1016	1.4E-01	1.4E-01	2.2E-05	99.98	8.9E-03	1.3E-01	6.6	1.3E-01	3.1E-04	0.25	1.5E-04
Aroclor 1221	1.4E-01	1.4E-01	3.9E-05	99.97	5.3E-03	1.3E-01	3.9	1.3E-01	2.6E-04	0.20	9.2E-05
Aroclor 1242	1.4E-01	1.4E-01	1.7E-05	99.99	1.1E-02	1.2E-01	8.3	1.2E-01	3.5E-04	0.28	1.9E-04
Aroclor 1248	1.4E-01	1.4E-01	1.7E-05	99.99	1.2E-02	1.2E-01	8.7	1.2E-01	3.5E-04	0.29	2.0E-04
Aroclor 1232	1.4E-01	1.4E-01	6.5E-04	99.52	7.0E-05	1.4E-01	0.05	1.4E-01	1.8E-04	0.13	4.2E-06
Aroclor 1254	1.4E-01	1.4E-01	1.6E-05	99.99	1.2E-02	1.2E-01	9.1	1.2E-01	3.6E-04	0.29	2.1E-04
Aroclor 1260	1.4E-01	1.4E-01	1.6E-05	99.99	1.2E-02	1.2E-01	9.1	1.2E-01	3.6E-04	0.29	2.1E-04
Averages	1.4E-01	1.4E-01	1.1E-04	99.92	8.9E-03	1.3E-01	6.5	1.3E-01	3.1E-04	0.25	1.5E-04

Constituent	CA-1 Slurry %	TK-C100 Condensate %	Vessel Vent %	Feed Conc µg/L	Slurry Conc µg/L	Process Condensate µg/L	VVent Conc µg/m3
Aroclor 1016	0.02	93.2	6.8	600	5.1E-01	660	590
Aroclor 1221	0.03	95.9	4.1	600	9.0E-01	680	360
Aroclor 1242	0.01	91.5	8.5	600	4.0E-01	650	750
Aroclor 1248	0.01	91.0	8.9	600	3.8E-01	640	780
Aroclor 1232	0.48	99.3	0.18	600	1.5E+01	700	16
Aroclor 1254	0.01	90.7	9.3	600	3.7E-01	640	820
Aroclor 1260	0.01	90.7	9.3	600	3.7E-01	640	820
Averages	0.08	93.2	6.7	600	2.6E+00	660	590

**The Evaporator Overall Partition Results for PCBs  
at 6000 µg/L PCB Aqueous Waste Feed**

Constituent	CA-1 Feed g/min	CA-1 Overheads g/min	CA-1 Slurry g/min	CA-1 Overheads %	EC-1/2/3 Overheads g/min	EC-1/2/3 Condensate g/min	EC-1/2/3 Overheads %	Process Condensate g/min	C-100 Overheads g/min	C-100 Overheads %	Vessel Vent g/sec
Aroclor 1016	1.4E+00	1.4E+00	2.2E-04	99.98	8.9E-02	1.3E+00	6.6	1.3E+00	3.1E-03	0.25	1.5E-03
Aroclor 1221	1.4E+00	1.4E+00	3.9E-04	99.97	5.3E-02	1.3E+00	3.9	1.3E+00	2.6E-03	0.20	9.2E-04
Aroclor 1242	1.4E+00	1.4E+00	1.7E-04	99.99	1.1E-01	1.2E+00	8.3	1.2E+00	3.5E-03	0.28	1.9E-03
Aroclor 1248	1.4E+00	1.4E+00	1.7E-04	99.99	1.2E-01	1.2E+00	8.7	1.2E+00	3.5E-03	0.29	2.0E-03
Aroclor 1232	1.4E+00	1.4E+00	6.5E-03	99.52	7.0E-04	1.4E+00	0.05	1.4E+00	1.8E-03	0.13	4.2E-05
Aroclor 1254	1.4E+00	1.4E+00	1.6E-04	99.99	1.2E-01	1.2E+00	9.1	1.2E+00	3.6E-03	0.29	2.1E-03
Aroclor 1260	1.4E+00	1.4E+00	1.6E-04	99.99	1.2E-01	1.2E+00	9.1	1.2E+00	3.6E-03	0.29	2.1E-03
Averages	1.4E+00	1.4E+00	1.1E-03	99.92	8.9E-02	1.3E+00	6.5	1.3E+00	3.1E-03	0.25	1.5E-03

Constituent	CA-1 Slurry %	TK-C100 Condensate %	Vessel Vent %	Feed Conc µg/L	Slurry Conc µg/L	Process Condensate µg/L	VVent Conc µg/m3
Aroclor 1016	0.02	93.2	6.8	6000	5.1E+00	6600	5900
Aroclor 1221	0.03	95.9	4.1	6000	9.0E+00	6800	3600
Aroclor 1242	0.01	91.5	8.5	6000	4.0E+00	6500	7500
Aroclor 1248	0.01	91.0	8.9	6000	3.8E+00	6400	7800
Aroclor 1232	0.48	99.3	0.18	6000	1.5E+02	7000	160
Aroclor 1254	0.01	90.7	9.3	6000	3.7E+00	6400	8200
Aroclor 1260	0.01	90.7	9.3	6000	3.7E+00	6400	8200
Averages	0.08	93.2	6.7	6000	2.6E+01	6600	5900

**PCB Emissions from ETF, Configuration 1  
at 0.20 µg/L PCB in Aqueous Waste Feed**

Constituent	Feed		Destroyed by UV/OX		To SALDS			Out of Stack		
	µg/L	g/min	g/min	wt %	µg/L	g/min	wt %	µg/m3	g/sec	wt %
Aroclor 1016	0.20	7.9E-05	7.7E-05	97%	3.2E-08	1.3E-11	0.000016%	1.6E-03	4.0E-08	3.0%
Aroclor 1221	0.20	7.9E-05	7.8E-05	98%	3.3E-08	1.3E-11	0.000017%	1.1E-03	2.7E-08	2.0%
Aroclor 1242	0.20	7.9E-05	7.7E-05	96%	3.2E-08	1.3E-11	0.000016%	2.0E-03	4.9E-08	3.7%
Aroclor 1248	0.20	7.9E-05	7.6E-05	96%	3.2E-08	1.3E-11	0.000016%	2.1E-03	5.2E-08	3.9%
Aroclor 1232	0.20	7.9E-05	7.9E-05	99.9%	3.4E-08	1.4E-11	0.000017%	6.2E-05	1.5E-09	0.1%
Aroclor 1254	0.20	7.9E-05	7.6E-05	96%	3.2E-08	1.3E-11	0.000016%	2.2E-03	5.5E-08	4.1%
Aroclor 1260	0.20	7.9E-05	7.6E-05	96%	3.2E-08	1.3E-11	0.000016%	2.2E-03	5.5E-08	4.1%
Averages:	0.20	7.9E-05	7.7E-05	97%	3.2E-08	1.3E-11	0.000016%	1.6E-03	4.0E-08	3.0%

**PCB Emissions from ETF, Configuration 1  
at 600 µg/L PCB in Aqueous Waste Feed**

Constituent	Feed		Destroyed by UV/OX		To SALDS			Out of Stack		
	µg/L	g/min	g/min	wt %	µg/L	g/min	wt %	µg/m3	g/sec	wt %
Aroclor 1016	600	2.4E-01	2.3E-01	97%	9.7E-05	3.9E-08	0.000016%	4.9E+00	1.2E-04	3.0%
Aroclor 1221	600	2.4E-01	2.3E-01	98%	9.9E-05	3.9E-08	0.000017%	3.3E+00	8.0E-05	2.0%
Aroclor 1242	600	2.4E-01	2.3E-01	96%	9.6E-05	3.8E-08	0.000016%	6.0E+00	1.5E-04	3.7%
Aroclor 1248	600	2.4E-01	2.3E-01	96%	9.5E-05	3.8E-08	0.000016%	6.4E+00	1.6E-04	3.9%
Aroclor 1232	600	2.4E-01	2.4E-01	99.9%	1.0E-04	4.1E-08	0.000017%	1.9E-01	4.6E-06	0.12%
Aroclor 1254	600	2.4E-01	2.3E-01	96%	9.5E-05	3.8E-08	0.000016%	6.7E+00	1.6E-04	4.1%
Aroclor 1260	600	2.4E-01	2.3E-01	96%	9.5E-05	3.8E-08	0.000016%	6.7E+00	1.6E-04	4.1%
Averages:	600	2.4E-01	2.3E-01	97%	9.7E-05	3.9E-08	0.000016%	4.9E+00	1.2E-04	3.0%

**PCB Emissions from ETF, Configuration 1  
 at 6000 µg/L PCB in Aqueous Waste Feed  
 (Continued)**

Constituent	Feed		Destroyed by UV/OX		To SALDS			Out of Stack		
	µg/L	g/min	g/min	wt %	µg/L	g/min	wt %	µg/m3	g/sec	wt %
Aroclor 1016	6000	2.4E+00	2.3E+00	97%	9.7E-04	3.9E-07	0.000016%	49	1.2E-03	3.0%
Aroclor 1221	6000	2.4E+00	2.3E+00	98%	9.9E-04	3.9E-07	0.000017%	33	8.0E-04	2.0%
Aroclor 1242	6000	2.4E+00	2.3E+00	96%	9.6E-04	3.8E-07	0.000016%	60	1.5E-03	3.7%
Aroclor 1248	6000	2.4E+00	2.3E+00	96%	9.5E-04	3.8E-07	0.000016%	64	1.6E-03	3.9%
Aroclor 1232	6000	2.4E+00	2.4E+00	99.9%	1.0E-03	4.1E-07	0.000017%	1.9	4.6E-05	0.12%
Aroclor 1254	6000	2.4E+00	2.3E+00	96%	9.5E-04	3.8E-07	0.000016%	67	1.6E-03	4.1%
Aroclor 1260	6000	2.4E+00	2.3E+00	96%	9.5E-04	3.8E-07	0.000016%	67	1.6E-03	4.1%
Averages:	6000	2.4E+00	2.3E+00	97%	9.7E-04	3.9E-07	0.000016%	49	1.2E-03	3.0%

**PCB Emissions from ETF, Configuration 3  
at 0.2 µg/L PCB in Aqueous Waste Feed**

Phase 1										
Constituent	Feed		Destroyed by UV/OX		Returned to LERF			Out of Stack		
	µg/L	g/min	g/min	wt %	µg/L	g/min	wt %	µg/m3	g/sec	wt %
Aroclor 1016	0.20	2.3E-05	NA	NA	0.17	1.9E-05	84%	2.4E-03	6.0E-08	16%
Aroclor 1221	0.20	2.3E-05	NA	NA	0.18	2.0E-05	89%	1.6E-03	4.0E-08	11%
Aroclor 1242	0.20	2.3E-05	NA	NA	0.16	1.8E-05	81%	2.9E-03	7.2E-08	19%
Aroclor 1248	0.20	2.3E-05	NA	NA	0.16	1.8E-05	80%	3.1E-03	7.6E-08	20%
Aroclor 1232	0.20	2.3E-05	NA	NA	0.20	2.3E-05	99%	9.5E-05	2.3E-09	0.62%
Aroclor 1254	0.20	2.3E-05	NA	NA	0.16	1.8E-05	79%	3.2E-03	7.9E-08	21%
Aroclor 1260	0.20	2.3E-05	NA	NA	0.16	1.8E-05	79%	3.2E-03	7.9E-08	21%
Averages:	0.20	2.3E-05	NA	NA	0.17	1.9E-05	85%	2.4E-03	5.8E-08	15%

Phase 2										
Constituent	Feed		Destroyed by UV/OX		To SALDS			Out of Stack		
	µg/L	g/min	g/min	wt %	µg/L	g/min	wt %	µg/m3	g/sec	wt %
Aroclor 1016	0.17	6.7E-05	6.5E-05	97%	2.7E-08	1.1E-11	0.000016%	1.4E-03	3.4E-08	3.0%
Aroclor 1221	0.18	7.1E-05	7.0E-05	98%	3.0E-08	1.2E-11	0.000017%	9.7E-04	2.4E-08	2.0%
Aroclor 1242	0.16	6.4E-05	6.2E-05	96%	2.6E-08	1.0E-11	0.000016%	1.6E-03	4.0E-08	3.7%
Aroclor 1248	0.16	6.4E-05	6.1E-05	96%	2.5E-08	1.0E-11	0.000016%	1.7E-03	4.2E-08	3.9%
Aroclor 1232	0.20	7.9E-05	7.9E-05	99.9%	3.4E-08	1.4E-11	0.000017%	6.2E-05	1.5E-09	0.12%
Aroclor 1254	0.16	6.3E-05	6.0E-05	96%	2.5E-08	1.0E-11	0.000016%	1.8E-03	4.3E-08	4.1%
Aroclor 1260	0.16	6.3E-05	6.0E-05	96%	2.5E-08	1.0E-11	0.000016%	1.8E-03	4.3E-08	4.1%
Averages:	0.17	6.7E-05	6.5E-05	97%	2.8E-08	1.1E-11	0.000016%	1.3E-03	3.2E-08	3.0%

**PCB Emissions from ETF, Configuration 3  
at 0.2 µg/L PCB in Aqueous Waste Feed  
(Continued)**

Constituent	Time-Weighted Average									
	Feed		Destroyed by UV/OX*		To SALDS*			Out of Stack		
	µg/L	g/min	g/min	wt %	µg/L	g/min	wt %	µg/m3	g/sec	wt %
Aroclor 1016	0.19	3.3E-05	2.9E-05	90%	2.7E-08	2.4E-12	0.000007%	2.2E-03	5.4E-08	10%
Aroclor 1221	0.20	3.3E-05	3.1E-05	93%	3.0E-08	2.6E-12	0.000008%	1.5E-03	3.7E-08	6.6%
Aroclor 1242	0.19	3.2E-05	2.8E-05	88%	2.6E-08	2.3E-12	0.000007%	2.6E-03	6.5E-08	12%
Aroclor 1248	0.19	3.2E-05	2.8E-05	87%	2.5E-08	2.2E-12	0.000007%	2.8E-03	6.8E-08	13%
Aroclor 1232	0.20	3.5E-05	3.5E-05	99.6%	3.4E-08	3.0E-12	0.000009%	8.8E-05	2.2E-09	0.37%
Aroclor 1254	0.19	3.2E-05	2.7E-05	87%	2.5E-08	2.2E-12	0.000007%	2.9E-03	7.1E-08	13%
Aroclor 1260	0.19	3.2E-05	2.7E-05	87%	2.5E-08	2.2E-12	0.000007%	2.9E-03	7.1E-08	13%
Averages:	0.19	3.3E-05	2.9E-05	90%	2.8E-08	2.4E-12	0.000007%	2.1E-03	5.3E-08	10%

**PCB Emissions from ETF, Configuration 3  
at 600 µg/L PCB in Aqueous Waste Feed**

Phase 1										
Constituent	Feed		Destroyed by UV/OX		Returned to LERF			Out of Stack		
	µg/L	g/min	g/min	wt %	µg/L	g/min	wt %	µg/m3	g/sec	wt %
Aroclor 1016	600	6.8E-02	NA	NA	504.79	5.7E-02	84%	7.3	1.8E-04	16%
Aroclor 1221	600	6.8E-02	NA	NA	536.31	6.1E-02	89%	4.9	1.2E-04	11%
Aroclor 1242	600	6.8E-02	NA	NA	485.80	5.5E-02	81%	8.8	2.2E-04	19%
Aroclor 1248	600	6.8E-02	NA	NA	479.55	5.4E-02	80%	9.3	2.3E-04	20%
Aroclor 1232	600	6.8E-02	NA	NA	596.29	6.8E-02	99%	0.29	7.0E-06	0.62%
Aroclor 1254	600	6.8E-02	NA	NA	475.02	5.4E-02	79%	9.6	2.4E-04	21%
Aroclor 1260	600	6.8E-02	NA	NA	475.02	5.4E-02	79%	9.6	2.4E-04	21%
Averages:	600	6.8E-02	NA	NA	507.54	5.8E-02	85%	7.1	1.7E-04	15%

Phase 2										
Constituent	Feed		Destroyed by UV/OX		To SALDS			Out of Stack		
	µg/L	g/min	g/min	wt %	µg/L	g/min	wt %	µg/m3	g/sec	wt %
Aroclor 1016	505	2.0E-01	1.9E-01	97%	8.2E-05	3.3E-08	0.000016%	4.1	1.0E-04	3.0%
Aroclor 1221	536	2.1E-01	2.1E-01	98%	8.9E-05	3.5E-08	0.000017%	2.9	7.2E-05	2.0%
Aroclor 1242	486	1.9E-01	1.9E-01	96%	7.8E-05	3.1E-08	0.000016%	4.8	1.2E-04	3.7%
Aroclor 1248	480	1.9E-01	1.8E-01	96%	7.6E-05	3.0E-08	0.000016%	5.1	1.3E-04	3.9%
Aroclor 1232	596	2.4E-01	2.4E-01	99.9%	1.0E-04	4.1E-08	0.000017%	0.19	4.5E-06	0.12%
Aroclor 1254	475	1.9E-01	1.8E-01	96%	7.5E-05	3.0E-08	0.000016%	5.3	1.3E-04	4.1%
Aroclor 1260	475	1.9E-01	1.8E-01	96%	7.5E-05	3.0E-08	0.000016%	5.3	1.3E-04	4.1%
Averages:	508	2.0E-01	2.0E-01	97%	8.3E-05	3.3E-08	0.000016%	4.0	9.7E-05	3.0%

**PCB Emissions from ETF, Configuration 3  
at 600 µg/L PCB in Aqueous Waste Feed  
(Continued)**

Constituent	Time-Weighted Average									
	Feed		Destroyed by UV/OX*		To SALDS*			Out of Stack		
	µg/L	g/min	g/min	wt %	µg/L	g/min	wt %	µg/m3	g/sec	wt %
Aroclor 1016	579	9.8E-02	8.8E-02	90%	8.2E-05	7.2E-09	0.000007%	6.6	1.6E-04	10%
Aroclor 1221	586	1.0E-01	9.4E-02	93%	8.9E-05	7.8E-09	0.000008%	4.5	1.1E-04	6.6%
Aroclor 1242	575	9.6E-02	8.4E-02	88%	7.8E-05	6.9E-09	0.000007%	7.9	1.9E-04	12%
Aroclor 1248	573	9.5E-02	8.3E-02	87%	7.6E-05	6.7E-09	0.000007%	8.4	2.1E-04	13%
Aroclor 1232	599	1.1E-01	1.1E-01	99.6%	1.0E-04	9.1E-09	0.000009%	0.26	6.5E-06	0.37%
Aroclor 1254	572	9.5E-02	8.2E-02	87%	7.5E-05	6.7E-09	0.000007%	8.7	2.1E-04	13%
Aroclor 1260	572	9.5E-02	8.2E-02	87%	7.5E-05	6.7E-09	0.000007%	8.7	2.1E-04	13%
Averages:	579	9.8E-02	8.8E-02	90%	8.3E-05	7.3E-09	0.000007%	6.4	1.6E-04	10%

**PCB Emissions from ETF, Configuration 3  
at 6000 µg/L PCB in Aqueous Waste Feed**

Phase 1										
Constituent	Feed		Destroyed by UV/OX		Returned to LERF			Out of Stack		
	µg/L	g/min	g/min	wt %	µg/L	g/min	wt %	µg/m3	g/sec	wt %
Aroclor 1016	6000	6.8E-01	NA	NA	5047.95	5.7E-01	84%	73	1.8E-03	16%
Aroclor 1221	6000	6.8E-01	NA	NA	5363.11	6.1E-01	89%	49	1.2E-03	11%
Aroclor 1242	6000	6.8E-01	NA	NA	4858.03	5.5E-01	81%	88	2.2E-03	19%
Aroclor 1248	6000	6.8E-01	NA	NA	4795.55	5.4E-01	80%	93	2.3E-03	20%
Aroclor 1232	6000	6.8E-01	NA	NA	5962.90	6.8E-01	99%	2.9	7.0E-05	0.62%
Aroclor 1254	6000	6.8E-01	NA	NA	4750.16	5.4E-01	79%	96	2.4E-03	21%
Aroclor 1260	6000	6.8E-01	NA	NA	4750.16	5.4E-01	79%	96	2.4E-03	21%
Averages:	6000	6.8E-01	NA	NA	5075.41	5.8E-01	85%	71	1.7E-03	15%

Phase 2										
Constituent	Feed		Destroyed by UV/OX		To SALDS			Out of Stack		
	µg/L	g/min	g/min	wt %	µg/L	g/min	wt %	µg/m3	g/sec	wt %
Aroclor 1016	5048	2.0E+00	1.9E+00	97%	8.2E-04	3.3E-07	0.000016%	41	1.0E-03	3.0%
Aroclor 1221	5363	2.1E+00	2.1E+00	98%	8.9E-04	3.5E-07	0.000017%	29	7.2E-04	2.0%
Aroclor 1242	4858	1.9E+00	1.9E+00	96%	7.8E-04	3.1E-07	0.000016%	48	1.2E-03	3.7%
Aroclor 1248	4796	1.9E+00	1.8E+00	96%	7.6E-04	3.0E-07	0.000016%	51	1.3E-03	3.9%
Aroclor 1232	5963	2.4E+00	2.4E+00	99.9%	1.0E-03	4.1E-07	0.000017%	1.9	4.5E-05	0.12%
Aroclor 1254	4750	1.9E+00	1.8E+00	96%	7.5E-04	3.0E-07	0.000016%	53	1.3E-03	4.1%
Aroclor 1260	4750	1.9E+00	1.8E+00	96%	7.5E-04	3.0E-07	0.000016%	53	1.3E-03	4.1%
Averages:	5075	2.0E+00	2.0E+00	97%	8.3E-04	3.3E-07	0.000016%	40	9.7E-04	3.0%

**PCB Emissions from ETF, Configuration 3  
at 6000 µg/L PCB in Aqueous Waste Feed  
(Continued)**

Constituent	Time-Weighted Average									
	Feed		Destroyed by UV/OX*		To SALDS*			Out of Stack		
	µg/L	g/min	g/min	wt %	µg/L	g/min	wt %	µg/m3	g/sec	wt %
Aroclor 1016	5788	9.8E-01	8.8E-01	90%	8.2E-04	7.2E-08	0.000007%	66	1.6E-03	10%
Aroclor 1221	5858	1.0E+00	9.4E-01	93%	8.9E-04	7.8E-08	0.000008%	45	1.1E-03	6.6%
Aroclor 1242	5746	9.6E-01	8.4E-01	88%	7.8E-04	6.9E-08	0.000007%	79	1.9E-03	12%
Aroclor 1248	5732	9.5E-01	8.3E-01	87%	7.6E-04	6.7E-08	0.000007%	84	2.1E-03	13%
Aroclor 1232	5992	1.1E+00	1.1E+00	99.6%	1.0E-03	9.1E-08	0.000009%	2.6	6.5E-05	0.37%
Aroclor 1254	5722	9.5E-01	8.2E-01	87%	7.5E-04	6.7E-08	0.000007%	87	2.1E-03	13%
Aroclor 1260	5722	9.5E-01	8.2E-01	87%	7.5E-04	6.7E-08	0.000007%	87	2.1E-03	13%
Averages:	5795	9.8E-01	8.8E-01	90%	8.3E-04	7.3E-08	0.000007%	64	1.6E-03	10%

### **A.2.3 Sample Calculation of Emission Rate**

The calculations of the PCB concentrations that would be emitted from the Evaporator stack for a single scenario are included in the attachment to this appendix. The PCB concentration in the waste feed from the Double-Shell Tanks to the Evaporator in this scenario is set at 0.2 µg/L. These calculations are included as a sample of the calculations performed to estimate PCB emission rates from the LWPF. Hand-written calculations have been completed for additional scenarios but are not included in the attachment due to the volume of paper that would be generated. These hand calculations are being provided in a separate letter to the EPA and will reference the Application and this appendix.

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### **A.3.0 RISK EVALUATION MODEL FOR PCB**

#### **A.3.1 Description of Model**

PCB concentrations were modeled for use in a risk assessment to the workers and to the public from operations at the Evaporator and the ETF. In all scenarios modeled, the risk to the workers and the public was less than  $1 \times 10^{-6}$ ; thus, processing of PCB wastewater at these two facilities does not provide an unacceptable risk.

Stack emissions from the Evaporator (296-A-22) and the ETF (296-E-1) were modeled to show release rates in g/s for the PCBs. A literature search of toxicity data revealed that Aroclor 1254 was the most toxic PCB mixture. In addition, Aroclor 1254 was the PCB mixture with the highest release rates from the model results shown in Section A.2.2. Therefore, Aroclor 1254 was selected as the bounding case for PCB mixtures. Aroclor 1254 emission rates were calculated in the model for the Evaporator and the model for the ETF (Configuration 1 and Configuration 3) at feed concentrations of 0.2  $\mu\text{g/L}$ , 600  $\mu\text{g/L}$  (the approximate PCB aqueous solubility limit), and 6000  $\mu\text{g/L}$ . The corresponding release rates from Section A.2.2 were used for the air dispersion modeling described below.

Air dispersion modeling using an EPA model (Industrial Source Complex 3, [ISC3]) provided maximum air concentrations of Aroclor 1254 at receptor locations. The air dispersion model provided unit concentration factors for a 1 g/s release for both 24-hour releases and annual releases that would yield air concentrations in  $\mu\text{g/m}^3$  per g/s release. The unit concentration factors for the locations with the highest average concentrations were multiplied by the release rates in g/s from the Evaporator and ETF models to estimate PCB air concentrations ( $\mu\text{g/m}^3$ ) resulting from the three feed concentrations modeled.

The Aroclor 1254 concentrations in the various scenarios were used to calculate risk to workers and to the public. Ecological risk was evaluated by comparing the combined PCB release rates from the Evaporator and ETF to the PCB release rates used in the *"Double-Shell Tank System PCB Risk Assessment"* (CHG 2001a).

#### **A.3.2 Air Dispersion Model for the Evaporator and the ETF**

The assumed stack characteristics are shown in Table A.3-1. The Evaporator vessel vent stack (296-A-22) has an effluent temperature that is well above ambient. This leads to significant buoyant plume rise. The ETF exhaust stack (296-E-1) is at the building interior temperature and has less plume rise. In addition, the high exit speeds lead to significant plume rise from momentum effects. Building wake effects were not included. It is assumed that these stacks are point sources at the height shown in Table A.3-1.

Stack Characteristic	Evaporator (296-A-22)	ETF (296-E-1)
Height	18.6 m (61 ft)	15.5 m (51 ft)
Diameter	0.2032 m (8 in)	1.829 m (6 ft)
Exhaust Flow Rate	0.260 m <sup>3</sup> /s (550 cfm)	26.0 m <sup>3</sup> /s (55,000 cfm)
Exit Speed	8.00 m/s (17.9 mph)	9.88 m/s (22.1 mph)
Temperature	338.7 K (150 F)	295.4 K (72 F)

**Table A.3-1 Stack Characteristics**

Air concentrations for 24-hour and annual releases from Evaporator and the Effluent Treatment Facility (ETF) have been calculated using the EPA guidance for the ISC3 model (EPA 1995a and EPA 1995b). The release rate is assumed to be 1 g/s. The resulting concentration factors are shown in Table A.3-2. These must be multiplied by the actual release rate (in g/s) over periods of either 24 hours or 8766 hours to give the average air concentrations for any chemical released.

For the 24-hour releases, the ISC Short-Term 3 (ISCST3) program was used. Hourly data collected at the 200 East Area wind tower (#8) from 1992 to 1996 was used in the calculations. For the annual releases, the ISC Long-Term 3 (ISCLT3) program was used. Average wind conditions for the years 1983 to 1996 were used in the calculations. The annual average ambient temperature is 11.8 C (PNNL 1996).

Distances from the evaporator and the ETF were computed using the Hanford Map Distance (HMD) software version 1.9 (Van Keuren 2000). These distances were computed both for 16 sectors (used by ISCLT3) and 36 sectors (used by ISCST3). The distances were rounded up to the next higher increment of 100 meters for these calculations. The distances computed by HMD are the shortest distance in the sector.

The distances used are shown in the ISC3 results tables provided in the air dispersion modeling report (Rittman 2002). Note that with elevated releases, the ground-level air concentration peaks at some distance. The peak air concentration was determined by calculating the air concentration in all sectors at various distances.

The regulatory default modeling options were used in the ISCLT3 input. These include using the final plume rise rather than the gradual plume rise model. However, due to gaps in the hourly wind data, the non-default option for processing missing data was used in the ISCST3 input. This option treats missing data as a calm condition.

Release Location	24 hour Releases		Annual Releases	
	Concentration Factor	Receptor Location	Concentration Factor	Receptor Location
Releases from the Evaporator (296-A-22)				
Onsite	63.8	0.40 km 120°	3.26	0.15 km SE
LIGO	1.17	13.7 km 150°	0.0477	13.7 km SSE
Energy NW	0.959	16.6 km 130°	0.0365	16.6 km SE
Site Boundary	1.10	22.3 km 340°	0.0472	19.8 km ESE
Releases from the Effluent Treatment Facility				
Onsite	17.3	0.10 km 130°	1.22	0.20 km SE
LIGO	0.974	14.7 km 140°	0.0205	14.7 km SE
Energy NW	0.76	17.4 km 130°	0.0334	17.4 km SE
Site Boundary	1.11	14.5 km 80°	0.0492	19.1 km ESE
Notes:				
<ul style="list-style-type: none"> <li>• Units for the Concentration Factors are µg/m<sup>3</sup> per g/s. Peak values are given.</li> <li>• The site boundary locations for 24-hour releases are given as distance and direction. The direction is measured in degrees clockwise from north.</li> <li>• Hanford site wind data collected over various periods was used to derive these numbers. The 24-hour averages are from hourly data for the years 1992 through 1996. All annual averages are computed from data collected over the years 1983 through 1996.</li> <li>• The 24-hour averages are calculated using 36-sector wind data and receptor locations. The annual averages are calculated using 16-sector wind data and receptor locations.</li> <li>• The distance and direction to the site boundary location with the largest average concentration is shown along with the concentration factor. In some cases the 24-hour and annual maximums are from different release locations within an area.</li> <li>• LIGO: Laser Interferometer Gravitational-wave Observatory</li> </ul>				
Source: (Rittman 2002)				

**Table A.3-2 ISC3 Concentration Factors for Unit Release Rates**

The ISCST3 results for 24-hour releases from the Evaporator and the ETF were calculated in the air dispersion modeling report (Rittman 2002) and summarized in Table A.3-2. These are the largest 24-hour air concentrations at the receptor location for a unit release rate. The directions shown are measured in degrees clockwise from north. These are transport directions, i.e., the direction traveled by the effluent as it travels from the facility to the receptor downwind. For the Evaporator stack releases, the peak value at onsite locations near the point of release is 400 meters. For ETF stack releases, the peak is at 100 meters. The Laser Interferometer Gravitational-wave Observatory (LIGO) and Energy Northwest results are shown in Table A.3-2 along with the Hanford Site boundary results.

The ISCLT3 results for annual emissions from the Evaporator and ETF are shown in Table A.3-2. These are the largest annual average air concentrations at the receptor location for a unit release rate. The transport directions shown in Table A.3-2 are the direction traveled by the effluent as it travels from the facility to the receptor downwind. For the Evaporator stack releases, the peak value at onsite locations near the point of release is 150 meters. For ETF stack releases, the peak is at 200 m. The LIGO and Energy Northwest results are shown in Table A.3-2 along with the Hanford Site boundary results. The large distances lead to results for the Evaporator and the ETF that are similar.

### A.3.3 Toxicity Evaluation

Standard toxicity values for PCBs are established in terms of the EPA's research and published guidelines (EPA 2000). The EPA has classified PCB as a probably human carcinogen (Class B2), without respect to specific Aroclors or congeners). Toxicity for PCBs is expressed in terms of reference dose (RfD) for non-carcinogenic effects and cancer slope factors (SF) for carcinogenic effects. A literature search revealed that RfDs for inhalation of PCBs have not been developed, so RfDs are not considered further in this risk evaluation. The EPA recommends that an upper-bound SF of  $0.4 \text{ (mg/kg-day)}^{-1}$  be used in human health risk assessments involving PCBs in the vapor phase (EPA 2000).

### A.3.4 Model Results for Exposure Concentrations

The unit concentration factors ( $\mu\text{g}/\text{m}^3$  per g/s) in Table A.2-2 were multiplied by the release rates (g/s) for Aroclor 1254 shown in the summary calculation spreadsheets in Section A.2.2 to estimate PCB concentrations ( $\mu\text{g}/\text{m}^3$ ) to which the workers and the public could be exposed. Using feed concentrations of  $0.2 \mu\text{g}/\text{L}$ ,  $600 \mu\text{g}/\text{L}$ , and  $6000 \mu\text{g}/\text{L}$  maximum Aroclor 1254 concentrations at ground level were calculated for 24-hour average concentrations (ISCST3) and annual average concentrations (ISCLT3) for the Evaporator and ETF in Configurations 1 and 3. ETF Configuration 3 was modeled using Phase 1 release rates for 24-hour average concentrations and the time-weighted Phase 1/Phase 3 release rates for annual average concentrations. The ISC3 model results for the Evaporator, ETF Configuration 1, and ETF Configuration 3 are shown in Tables A.3-3, A.3-4, and A.3-5, respectively.

The concentrations for worker exposures (both 24-hour averages and annual averages) were compared to the OSHA permissible exposure levels for PCBs ( $500 \mu\text{g}/\text{m}^3$  for an 8-hour time-weighted average). The highest concentration of worker exposure was  $0.13 \mu\text{g}/\text{m}^3$ , less than 0.03 percent of the OSHA standard.

<b>Evaporator Partition Model Results (See Section A.2.2)</b>			
<b>Feed Concentration</b>	<b>0.2 µg/L</b>	<b>600 µg/L</b>	<b>6000 µg/L</b>
Vessel Vent Release Rate	$7.1 \times 10^{-8}$ g/s	$2.1 \times 10^{-4}$ g/s	$2.1 \times 10^{-3}$ g/s
Vessel Vent Concentration	$2.7 \times 10^{-1}$ µg/m <sup>3</sup>	$8.2 \times 10^2$ µg/m <sup>3</sup>	$8.2 \times 10^3$ µg/m <sup>3</sup>
<b>PCB (as Aroclor 1254) Concentration to Public Receptor</b>			
Highest 24-Hour Average Concentration	$8.3 \times 10^{-8}$ µg/m <sup>3</sup>	$2.5 \times 10^{-4}$ µg/m <sup>3</sup>	$2.5 \times 10^{-3}$ µg/m <sup>3</sup>
Highest Annual Average Concentration	$3.4 \times 10^{-9}$ µg/m <sup>3</sup>	$1.0 \times 10^{-5}$ µg/m <sup>3</sup>	$1.0 \times 10^{-4}$ µg/m <sup>3</sup>
<b>PCB (as Aroclor 1254) Concentration to Worker</b>			
Highest 24-Hour Average Concentration	$4.5 \times 10^{-6}$ µg/m <sup>3</sup>	$1.3 \times 10^{-2}$ µg/m <sup>3</sup>	$1.3 \times 10^{-1}$ µg/m <sup>3</sup>
Highest Annual Average Concentration	$2.3 \times 10^{-7}$ µg/m <sup>3</sup>	$6.8 \times 10^{-4}$ µg/m <sup>3</sup>	$6.8 \times 10^{-4}$ µg/m <sup>3</sup>
<b>OSHA Permissible Exposure Level (8-hr Time Weighted Average)</b>	<b>500 µg/m<sup>3</sup></b>	<b>500 µg/m<sup>3</sup></b>	<b>500 µg/m<sup>3</sup></b>

**Table A.3-3 ISC3 Model Results for the Evaporator.**

<b>ETF Configuration 1 Model Results (See Section A.2.2)</b>			
<b>Feed Concentration</b>	<b>0.2 µg/L</b>	<b>600 µg/L</b>	<b>6000 µg/L</b>
Vessel Vent Release Rate	$5.5 \times 10^{-8}$ g/s	$1.6 \times 10^{-4}$ g/s	$1.6 \times 10^{-3}$ g/s
Vessel Vent Concentration	$2.2 \times 10^{-3}$ µg/m <sup>3</sup>	$6.7 \times 10^0$ µg/m <sup>3</sup>	$6.7 \times 10^1$ µg/m <sup>3</sup>
<b>PCB Concentration (as Aroclor 1254) to Public Receptor</b>			
Highest 24-Hour Average Concentration	$6.1 \times 10^{-8}$ µg/m <sup>3</sup>	$1.8 \times 10^{-4}$ µg/m <sup>3</sup>	$1.8 \times 10^{-3}$ µg/m <sup>3</sup>
Highest Annual Average Concentration	$2.7 \times 10^{-9}$ µg/m <sup>3</sup>	$7.9 \times 10^{-6}$ µg/m <sup>3</sup>	$7.9 \times 10^{-5}$ µg/m <sup>3</sup>
<b>PCB Concentration (as Aroclor 1254) to Worker</b>			
Highest 24-Hour Average Concentration	$9.5 \times 10^{-7}$ µg/m <sup>3</sup>	$2.8 \times 10^{-3}$ µg/m <sup>3</sup>	$2.8 \times 10^{-2}$ µg/m <sup>3</sup>
Highest Annual Average Concentration	$6.7 \times 10^{-8}$ µg/m <sup>3</sup>	$1.9 \times 10^{-4}$ µg/m <sup>3</sup>	$1.9 \times 10^{-3}$ µg/m <sup>3</sup>
<b>OSHA Permissible Exposure Level (8-hr Time Weighted Average)</b>	<b>500 µg/m<sup>3</sup></b>	<b>500 µg/m<sup>3</sup></b>	<b>500 µg/m<sup>3</sup></b>

**Table A.3-4 ISC3 Model Results for ETF Configuration 1.**

<b>ETF Configuration 3 Model Results (See Section A.2.2)</b>			
<b>Feed Concentration</b>	<b>0.2 µg/L</b>	<b>600 µg/L</b>	<b>6000 µg/L</b>
Vessel Vent Release Rate	$7.9 \times 10^{-8}$ g/s	$2.4 \times 10^{-4}$ g/s	$2.4 \times 10^{-3}$ g/s
Vessel Vent Concentration	$3.2 \times 10^{-3}$ µg/m <sup>3</sup>	$9.6 \times 10^0$ µg/m <sup>3</sup>	$9.6 \times 10^1$ µg/m <sup>3</sup>
<b>PCB Concentration (as Aroclor 1254) to Public Receptor</b>			
Highest 24-Hour Average Concentration	$8.8 \times 10^{-8}$ µg/m <sup>3</sup>	$2.7 \times 10^{-4}$ µg/m <sup>3</sup>	$2.7 \times 10^{-3}$ µg/m <sup>3</sup>
Highest Annual Average Concentration	$3.5 \times 10^{-9}$ µg/m <sup>3</sup>	$1.0 \times 10^{-5}$ µg/m <sup>3</sup>	$1.0 \times 10^{-4}$ µg/m <sup>3</sup>
<b>PCB Concentration (as Aroclor 1254) to Worker</b>			
Highest 24-Hour Average Concentration	$1.4 \times 10^{-6}$ µg/m <sup>3</sup>	$4.2 \times 10^{-3}$ µg/m <sup>3</sup>	$4.2 \times 10^{-2}$ µg/m <sup>3</sup>
Highest Annual Average Concentration	$8.6 \times 10^{-8}$ µg/m <sup>3</sup>	$2.6 \times 10^{-4}$ µg/m <sup>3</sup>	$2.6 \times 10^{-3}$ µg/m <sup>3</sup>
<b>OSHA Permissible Exposure Level (8-hr Time Weighted Average)</b>	<b>500 µg/m<sup>3</sup></b>	<b>500 µg/m<sup>3</sup></b>	<b>500 µg/m<sup>3</sup></b>

**Table A.3-5 ISC3 Model Results for ETF Configuration 3.**

### A.3.5 Human Risk Characterization

Human risk calculations were performed using the same methodology as used in the evaporation campaign 2001-01 for the feed concentrations of 0.2 µg/L, 600 µg/L, and 6000 µg/L. Aroclor 1254 concentrations were calculated for both 24-hour and annual averages at the locations of highest public exposure (considering LIGO, Energy Northwest, and the Hanford Site boundary) and the worker exposure (ranging from 100 meters to 400 meters from the respective stacks). The human risk calculation results for exposure to PCBs from the Evaporator, ETF Configuration 1, and ETF Configuration 3 are shown in Tables A.3-6, A.3-7, and A.3-8, respectively.

The calculated risk is the product of the lifetime average daily dose (LADD), in mg/kg-day, and the slope factor,  $0.4 \text{ (mg/kg-day)}^{-1}$ . The LADD is the product of the exposure concentration (air dispersion modeling results, in  $\mu\text{g}/\text{m}^3$ ), the intake rate (assumed as  $20 \text{ m}^3/\text{day}$ ), and the exposure duration (in years) divided by the body weight (BW) (assumed as 70 kg) and the lifetime (assumed as 70 years). The exposure concentration is from the ISC3 air dispersion modeling results (Section A.3.4). The ISC3 dispersion model calculated the highest 24-hour average concentrations and the highest annual average concentrations, assuming a constant release rate for the entire year (8766 hours). The exposure duration for the public assumed 20 years of exposure at 8766 hours per year. The exposure duration for the workers at the Evaporator and the ETF factored in operating times, as explained below.

The Evaporator was assumed to operate 30 days per year (i.e., 1 month, or 1/12 year) for a period of 20 years. A worker was assumed to work 2000 hours per year and was assumed to be subjected to 167 hours per year exposure (2000/12) for a period of 20 years, for a total exposure duration of 0.38 year.

The ETF was assumed to operate 85 percent of the time for a period of 20 years. A worker was assumed to work 2000 hours per year and was assumed to be subjected to 1700 hours per year exposure (85% of 2000) for a period of 20 years, for a total exposure duration of 3.9 years.

Combined risk was calculated for each receptor location using the following two exposure scenarios: 1) annual average concentrations, and 2) maximum 24-hour average concentrations. The combined human risk calculation results were less than  $1 \times 10^{-6}$  for both cases for all three feed concentrations (0.2 µg/L, 600 µg/L, and 6000 µg/L). Annual average concentrations of PCBs emitted from the LWPF provide the best estimate for human risk calculations, as these concentrations gave the most representative values over time. The maximum 24-hour average concentrations were not appropriate for establishing human health risk due to the variability of prevailing wind direction and the fact that the Evaporator and the ETF had different receptor points of maximum exposure based on air dispersion modeling. The combined human risk calculation results for exposure to PCBs from the Evaporator and the ETF Configuration 3 are shown in Table A.3-9.

<b>Lifetime Average Daily Dose (LADD) = (C*IR*ED)/(BW*LT)</b>				<b>Risk = LADD * Slope, using slope of 0.4 (mg/kg-day)<sup>-1</sup></b>			
Pathway (vapor inhalation)	C (concentration, µg/m <sup>3</sup> )	IR (intake rate, m <sup>3</sup> /day)	ED (exposure duration)	BW (body weight, kg)	LT (lifetime, yr)	LADD (mg/kg-day)	Risk (LADD * Slope)
<b>Evaporator</b>							
<b>Public Receptor</b> (8766 hr/yr exposure)							
<b>Highest 24-Hour Average Concentration</b>							
0.2 µg/L Feed Concentration	8.3 x 10 <sup>-8</sup>	20	20	70	70	6.8 x 10 <sup>-12</sup>	2.7 x 10 <sup>-12</sup>
600 µg/L Feed Concentration	2.5 x 10 <sup>-4</sup>	20	20	70	70	2.0 x 10 <sup>-8</sup>	8.0 x 10 <sup>-9</sup>
6000 µg/L Feed Concentration	2.5 x 10 <sup>-3</sup>	20	20	70	70	2.0 x 10 <sup>-7</sup>	8.0 x 10 <sup>-8</sup>
<b>Highest Annual Average Concentration</b>							
0.2 µg/L Feed Concentration	3.4 x 10 <sup>-9</sup>	20	20	70	70	2.7 x 10 <sup>-13</sup>	1.1 x 10 <sup>-13</sup>
600 µg/L Feed Concentration	1.0 x 10 <sup>-5</sup>	20	20	70	70	8.2 x 10 <sup>-10</sup>	3.3 x 10 <sup>-10</sup>
6000 µg/L Feed Concentration	1.0 x 10 <sup>-4</sup>	20	20	70	70	8.2 x 10 <sup>-9</sup>	3.3 x 10 <sup>-9</sup>
<b>Worker</b> (1 campaign/yr for 20 yrs)							
<b>Highest 24-Hour Average Concentration</b>							
0.2 µg/L Feed Concentration	4.5 x 10 <sup>-6</sup>	20	0.38	70	70	7.0 x 10 <sup>-12</sup>	2.8 x 10 <sup>-12</sup>
600 µg/L Feed Concentration	1.3 x 10 <sup>-2</sup>	20	0.38	70	70	2.1 x 10 <sup>-8</sup>	8.3 x 10 <sup>-9</sup>
6000 µg/L Feed Concentration	1.3 x 10 <sup>-1</sup>	20	0.38	70	70	2.1 x 10 <sup>-7</sup>	8.3 x 10 <sup>-8</sup>
<b>Highest Annual Average Concentration</b>							
0.2 µg/L Feed Concentration	2.3 x 10 <sup>-7</sup>	20	0.38	70	70	3.6 x 10 <sup>-13</sup>	1.4 x 10 <sup>-13</sup>
600 µg/L Feed Concentration	6.8 x 10 <sup>-4</sup>	20	0.38	70	70	1.1 x 10 <sup>-9</sup>	4.3 x 10 <sup>-10</sup>
6000 µg/L Feed Concentration	6.8 x 10 <sup>-3</sup>	20	0.38	70	70	1.1 x 10 <sup>-8</sup>	4.3 x 10 <sup>-9</sup>

**Table A.3-6 Human Risk Calculations for the Evaporator.**

<b>Lifetime Average Daily Dose (LADD) = (C*IR*ED)/(BW*LT)</b>				<b>Risk = LADD * Slope, using slope of 0.4 (mg/kg-day)<sup>-1</sup></b>			
Pathway (vapor inhalation)	C (concentration, µg/m <sup>3</sup> )	IR (intake rate, m <sup>3</sup> /day)	ED (exposure duration)	BW (body weight, kg)	LT (lifetime, yr)	LADD (mg/kg-day)	Risk (LADD * Slope)
<b>ETF Configuration 1</b>							
<b>Public Receptor</b> (8766 hr/yr exposure)							
<b>Highest 24-Hour Average Concentration</b>							
0.2 µg/L Feed Concentration	6.1 x 10 <sup>-8</sup>	20	20	70	70	5.0 x 10 <sup>-12</sup>	2.0 x 10 <sup>-12</sup>
600 µg/L Feed Concentration	1.8 x 10 <sup>-4</sup>	20	20	70	70	1.4 x 10 <sup>-8</sup>	5.8 x 10 <sup>-9</sup>
6000 µg/L Feed Concentration	1.8 x 10 <sup>-3</sup>	20	20	70	70	1.4 x 10 <sup>-7</sup>	5.8 x 10 <sup>-8</sup>
<b>Highest Annual Average Concentration</b>							
0.2 µg/L Feed Concentration	2.7 x 10 <sup>-9</sup>	20	20	70	70	2.2 x 10 <sup>-13</sup>	8.8 x 10 <sup>-14</sup>
600 µg/L Feed Concentration	7.9 x 10 <sup>-6</sup>	20	20	70	70	6.4 x 10 <sup>-10</sup>	2.6 x 10 <sup>-10</sup>
6000 µg/L Feed Concentration	7.9 x 10 <sup>-5</sup>	20	20	70	70	6.4 x 10 <sup>-9</sup>	2.6 x 10 <sup>-9</sup>
<b>Worker</b> (2000 hrs/yr for 20 yrs)							
<b>Highest 24-Hour Average Concentration</b>							
0.2 µg/L Feed Concentration	9.5 x 10 <sup>-7</sup>	20	3.9	70	70	1.5 x 10 <sup>-11</sup>	6.0 x 10 <sup>-12</sup>
600 µg/L Feed Concentration	2.8 x 10 <sup>-3</sup>	20	3.9	70	70	4.4 x 10 <sup>-8</sup>	1.8 x 10 <sup>-8</sup>
6000 µg/L Feed Concentration	2.8 x 10 <sup>-2</sup>	20	3.9	70	70	4.4 x 10 <sup>-7</sup>	1.8 x 10 <sup>-7</sup>
<b>Highest Annual Average Concentration</b>							
0.2 µg/L Feed Concentration	6.7x 10 <sup>-8</sup>	20	3.9	70	70	1.1 x 10 <sup>-12</sup>	4.2 x 10 <sup>-13</sup>
600 µg/L Feed Concentration	1.9 x 10 <sup>-4</sup>	20	3.9	70	70	3.1 x 10 <sup>-9</sup>	1.2 x 10 <sup>-9</sup>
6000 µg/L Feed Concentration	1.9 x 10 <sup>-3</sup>	20	3.9	70	70	3.1 x 10 <sup>-8</sup>	1.2 x 10 <sup>-8</sup>

**Table A.3-7 Human Risk Calculations for the ETF Configuration 1.**

<b>Lifetime Average Daily Dose (LADD) = (C*IR*ED)/(BW*LT)</b>				<b>Risk = LADD * Slope, using slope of 0.4 (mg/kg-day)<sup>-1</sup></b>			
Pathway (vapor inhalation)	C (concentration, µg/m <sup>3</sup> )	IR (intake rate, m <sup>3</sup> /day)	ED (exposure duration)	BW (body weight, kg)	LT (lifetime, yr)	LADD (mg/kg-day)	Risk (LADD * Slope)
<b>ETF Configuration 3</b>							
<b>Public Receptor</b> (8766 hr/yr exposure)							
<b>Highest 24-Hour Average Concentration</b>							
0.2 µg/L Feed Concentration	8.8 x 10 <sup>-8</sup>	20	20	70	70	7.2 x 10 <sup>-12</sup>	2.9 x 10 <sup>-12</sup>
600 µg/L Feed Concentration	2.7 x 10 <sup>-4</sup>	20	20	70	70	2.2 x 10 <sup>-8</sup>	8.7 x 10 <sup>-9</sup>
6000 µg/L Feed Concentration	2.7 x 10 <sup>-3</sup>	20	20	70	70	2.2 x 10 <sup>-7</sup>	8.7 x 10 <sup>-8</sup>
<b>Highest Annual Average Concentration</b>							
0.2 µg/L Feed Concentration	3.5 x 10 <sup>-9</sup>	20	20	70	70	2.9 x 10 <sup>-13</sup>	1.1 x 10 <sup>-13</sup>
600 µg/L Feed Concentration	1.0 x 10 <sup>-5</sup>	20	20	70	70	8.4 x 10 <sup>-10</sup>	3.4 x 10 <sup>-10</sup>
6000 µg/L Feed Concentration	1.0 x 10 <sup>-4</sup>	20	20	70	70	8.4 x 10 <sup>-9</sup>	3.4 x 10 <sup>-9</sup>
<b>Worker</b> (2000 hrs/yr for 20 yrs)							
<b>Highest 24-Hour Average Concentration</b>							
0.2 µg/L Feed Concentration	1.4 x 10 <sup>-6</sup>	20	3.9	70	70	2.2 x 10 <sup>-11</sup>	8.7 x 10 <sup>-12</sup>
600 µg/L Feed Concentration	4.2 x 10 <sup>-3</sup>	20	3.9	70	70	6.6 x 10 <sup>-8</sup>	2.6 x 10 <sup>-8</sup>
6000 µg/L Feed Concentration	4.2 x 10 <sup>-2</sup>	20	3.9	70	70	6.6 x 10 <sup>-7</sup>	2.6 x 10 <sup>-7</sup>
<b>Highest Annual Average Concentration</b>							
0.2 µg/L Feed Concentration	8.6 x 10 <sup>-8</sup>	20	3.9	70	70	1.4 x 10 <sup>-13</sup>	5.5 x 10 <sup>-13</sup>
600 µg/L Feed Concentration	2.6 x 10 <sup>-4</sup>	20	3.9	70	70	4.0 x 10 <sup>-9</sup>	1.6 x 10 <sup>-9</sup>
6000 µg/L Feed Concentration	2.6 x 10 <sup>-3</sup>	20	3.9	70	70	4.0 x 10 <sup>-8</sup>	1.6 x 10 <sup>-8</sup>

**Table A.3-8 Human Risk Calculations for the ETF Configuration 3.**

Feed Concentration	0.2 µg/L	600 µg/L	6000 µg/L
<b>Public Receptor Risk</b>			
LIGO Receptor Risk Using Highest 24-hr Average Concentration	$5.7 \times 10^{-12}$ µg/m <sup>3</sup>	$1.6 \times 10^{-08}$ µg/m <sup>3</sup>	$1.6 \times 10^{-07}$ µg/m <sup>3</sup>
LIGO Receptor Risk Using Annual Average Concentration	$1.6 \times 10^{-13}$ µg/m <sup>3</sup>	$4.7 \times 10^{-10}$ µg/m <sup>3</sup>	$4.7 \times 10^{-09}$ µg/m <sup>3</sup>
Energy Northwest Receptor Risk Using Highest 24-hr Average Concentration	$4.3 \times 10^{-12}$ µg/m <sup>3</sup>	$1.3 \times 10^{-08}$ µg/m <sup>3</sup>	$1.3 \times 10^{-07}$ µg/m <sup>3</sup>
Energy Northwest Receptor Risk Using Annual Average Concentration	$1.6 \times 10^{-13}$ µg/m <sup>3</sup>	$4.8 \times 10^{-10}$ µg/m <sup>3</sup>	$4.8 \times 10^{-09}$ µg/m <sup>3</sup>
Site Boundary Receptor Risk Using Highest 24-hr Average Concentration	$5.6 \times 10^{-12}$ µg/m <sup>3</sup>	$1.7 \times 10^{-08}$ µg/m <sup>3</sup>	$1.7 \times 10^{-07}$ µg/m <sup>3</sup>
Site Boundary Receptor Risk Using Annual Average Concentration	$2.2 \times 10^{-13}$ µg/m <sup>3</sup>	$6.6 \times 10^{-10}$ µg/m <sup>3</sup>	$6.6 \times 10^{-09}$ µg/m <sup>3</sup>
<b>Worker Risk</b>			
Worker Receptor Risk Using Highest 24-hr Average Concentration	$1.1 \times 10^{-11}$ µg/m <sup>3</sup>	$3.5 \times 10^{-08}$ µg/m <sup>3</sup>	$3.5 \times 10^{-07}$ µg/m <sup>3</sup>
Worker Receptor Risk Using Highest Annual Average Concentration	$6.9 \times 10^{-13}$ µg/m <sup>3</sup>	$2.0 \times 10^{-09}$ µg/m <sup>3</sup>	$2.0 \times 10^{-08}$ µg/m <sup>3</sup>

**Table A.3-9 Combined Evaporator and the ETF (Configuration 3)  
Human Risk Assessment Summary**

### A.3.6 Ecological Risk Characterization

Ecological risk from PCB emissions from the LWPF was based on the evaluation performed for the DST system (CHG 2001a). The DST evaluation was based on a combined release rate for PCBs (Aroclor 1016) of 0.0017 g/s. The LWPF release rates were compared to the DST release rates. The DST releases of PCBs occur 8766 hours per year. The LWPF releases occur only during operations. A ratio was established between the LWPF and the DSTs, factoring in the periods of operation. This formula for establishing the ratio is as follows:

The sum of the release rates for the Evaporator plus ETF Configuration 1 (the standard operating configuration) at each of the three feed concentrations was divided by the release rate for the DSTs (0.0017 g/s). For the 0.2 µg/L feed rate scenario, the result was a factor of  $3.1 \times 10^{-5}$ . For the 600 µg/L feed rate scenario, the result was a factor of  $9.0 \times 10^{-2}$ . For the 6,000 µg/L feed rate scenario, the result was a factor of  $9.0 \times 10^{-1}$ . This comparison is considered conservative due to the facility specific factors that are present at the LWPF. For example, the stack height, air discharge velocity, and elevated temperature (at the Evaporator) provide greater dispersion than the ground-level releases modeled for the DST risk assessment.

The ratios established for each of the three scenarios were used to derive anticipated dose for ecological receptors by multiplying the ratio by the anticipated dose used in the DST risk assessment (CHG 2001a). These results are shown in Tables A.3-10, A.3-11, and A.3.12.

<b>Ecological Receptor (Common Name)</b>	<b>DST Anticipated Total Dose or Concentration</b>	<b>LWPF:DST Release Rate Ratio</b>	<b>LWPF Anticipated Total Dose or Concentration</b>
<b>FISH</b> Rainbow Trout / Steelhead	$7.8 \times 10^{-4}$ µg/L	$3.1 \times 10^{-5}$	$2.4 \times 10^{-8}$ µg/L
<b>BIRDS</b> Red-tailed Hawk	$6.4 \times 10^{-4}$ mg/kg-day	$3.1 \times 10^{-5}$	$2.0 \times 10^{-8}$ mg/kg-day
Great Blue Heron	$2.9 \times 10^{-2}$ mg/kg-day	$3.1 \times 10^{-5}$	$9.0 \times 10^{-7}$ mg/kg-day
American Robin	$6.3 \times 10^{-2}$ mg/kg-day	$3.1 \times 10^{-5}$	$2.0 \times 10^{-6}$ mg/kg-day
<b>MAMMALS</b> White-tailed Deer	$2.4 \times 10^{-3}$ mg/kg-day	$3.1 \times 10^{-5}$	$7.4 \times 10^{-8}$ mg/kg-day
Mink	$1.2 \times 10^{-2}$ mg/kg-day	$3.1 \times 10^{-5}$	$3.7 \times 10^{-7}$ mg/kg-day
Meadow Vole	$2.9 \times 10^{-2}$ mg/kg-day	$3.1 \times 10^{-5}$	$9.0 \times 10^{-7}$ mg/kg-day
<b>PLANTS</b> Pigweed	$4.3 \times 10^{-2}$ mg/kg	$3.1 \times 10^{-5}$	$1.3 \times 10^{-6}$ mg/kg

**Table A.3-10 Dose or Concentration to Ecological Receptors at 0.2 µg/L PCB  
in Wastewater Received by LWPF.**

<b>Ecological Receptor (Common Name)</b>	<b>DST Anticipated Total Dose or Concentration</b>	<b>LWPF:DST Release Rate Ratio</b>	<b>LWPF Anticipated Total Dose or Concentration</b>
<b>FISH</b> Rainbow Trout / Steelhead	$7.8 \times 10^{-4}$ µg/L	$9.0 \times 10^{-2}$	$7.0 \times 10^{-5}$ µg/L
<b>BIRDS</b> Red-tailed Hawk	$6.4 \times 10^{-4}$ mg/kg-day	$9.0 \times 10^{-2}$	$5.8 \times 10^{-5}$ mg/kg-day
Great Blue Heron	$2.9 \times 10^{-2}$ mg/kg-day	$9.0 \times 10^{-2}$	$2.6 \times 10^{-3}$ mg/kg-day
American Robin	$6.3 \times 10^{-2}$ mg/kg-day	$9.0 \times 10^{-2}$	$5.7 \times 10^{-3}$ mg/kg-day
<b>MAMMALS</b> White-tailed Deer	$2.4 \times 10^{-3}$ mg/kg-day	$9.0 \times 10^{-2}$	$2.2 \times 10^{-4}$ mg/kg-day
Mink	$1.2 \times 10^{-2}$ mg/kg-day	$9.0 \times 10^{-2}$	$1.1 \times 10^{-3}$ mg/kg-day
Meadow Vole	$2.9 \times 10^{-2}$ mg/kg-day	$9.0 \times 10^{-2}$	$2.6 \times 10^{-3}$ mg/kg-day
<b>PLANTS</b> Pigweed	$4.3 \times 10^{-2}$ mg/kg	$9.0 \times 10^{-2}$	$3.9 \times 10^{-3}$ mg/kg

**Table A.3-11 Dose or Concentration to Ecological Receptors at 600 µg/L PCB  
in Wastewater Received by LWPF.**

<b>Ecological Receptor (Common Name)</b>	<b>DST Anticipated Total Dose or Concentration</b>	<b>LWPF:DST Release Rate Ratio</b>	<b>LWPF Anticipated Total Dose or Concentration</b>
<b>FISH</b> Rainbow Trout / Steelhead	$7.8 \times 10^{-4}$ µg/L	$9.0 \times 10^{-1}$	$7.0 \times 10^{-4}$ µg/L
<b>BIRDS</b> Red-tailed Hawk	$6.4 \times 10^{-4}$ mg/kg-day	$9.0 \times 10^{-1}$	$5.8 \times 10^{-4}$ mg/kg-day
Great Blue Heron	$2.9 \times 10^{-2}$ mg/kg-day	$9.0 \times 10^{-1}$	$2.6 \times 10^{-2}$ mg/kg-day
American Robin	$6.3 \times 10^{-2}$ mg/kg-day	$9.0 \times 10^{-1}$	$5.7 \times 10^{-2}$ mg/kg-day
<b>MAMMALS</b> White-tailed Deer	$2.4 \times 10^{-3}$ mg/kg-day	$9.0 \times 10^{-1}$	$2.2 \times 10^{-3}$ mg/kg-day
Mink	$1.2 \times 10^{-2}$ mg/kg-day	$9.0 \times 10^{-1}$	$1.1 \times 10^{-3}$ mg/kg-day
Meadow Vole	$2.9 \times 10^{-2}$ mg/kg-day	$9.0 \times 10^{-1}$	$2.6 \times 10^{-2}$ mg/kg-day
<b>PLANTS</b> Pigweed	$4.3 \times 10^{-2}$ mg/kg	$9.0 \times 10^{-1}$	$3.9 \times 10^{-2}$ mg/kg

**Table A.3-12 Dose or Concentration to Ecological Receptors at  
6000 µg/L PCB in Wastewater Received by LWPF.**

### A.3.7 Uncertainty Analysis

Assumptions used in the model for PCB emissions from the LWPF, the model for dispersion of PCBs in the air pathway, and the models for estimating human health and ecological impacts are all estimates and should not be interpreted as absolute values. A conservative approach is used in most cases, to show a worst-case scenario that would result in the highest risk to human health or the environment. Average values were used in some cases, which may result in an estimated risk that is either higher or lower than the actual risk. Examples of uncertainties in this risk evaluation are as follows:

**Evaporator Operating Temperature** – The operating temperature of the EC-1 Condenser, a component of the Evaporator, is a key factor in the percent of PCBs that is driven off to the air pathway through the stack and the percent of PCBs that enters the process condensate. The operating temperature of this condenser is not controlled manually, but is a function of the cooling water temperature, which depends on Columbia River water temperature. As the temperature of the condenser increases, the percentage of PCBs emitted to the air pathway via the stack also increases. The condenser temperature historically ranges from 34°C to 44°C, with an average of 40°C. The average temperature of 40°C is used in the PCB emission model for the Evaporator. Therefore, the actual percentage of PCBs emitted to the air pathway may be either understated or overstated, depending on the actual condenser temperature.

**Decontamination Factor for PCBs in UV Oxidation** – The DF used in this risk evaluation is 11,600, as specified in the August 1993 Delisting Petition (RL 1993). A revised Delisting Petition is in preparation at this time for the purpose of adding landfill leachate to the list of delisted wastes following treatment at the ETF. The new petition includes updated information on the DF for PCBs in the UV oxidation process and the new DF is set at approximately 19,000. This means that the risk of PCB emissions in this risk evaluation may be overstated by approximately one-third.

**Exposure Assessment** – The estimated PCB concentration at each point of exposure is based on conservative assumptions (e.g., the air dispersion modeling assumed that the release rates of PCBs from the Evaporator and the ETF were sustained for all 8766 hours per year). This results in a bias towards higher average concentrations of PCBs in the air. This assumption results in an overstatement of exposure and resultant human health risk.

**Cancer Slope Factor** – The SF is a measure of toxicity of a chemical, in terms of its capability to produce cancer. The upper-bound SF of  $0.4 \text{ (mg/kg-day)}^{-1}$  for vapor phase emissions is used in the human health risk evaluation as the most conservative assumption. The actual toxicity is not expected to exceed the upper-bound SF.

**Public Risk Evaluation** – Public risk was based on exposure for 8766 hours per year for twenty years, although the actual period of exposure is much less based on facility operations (e.g., the Evaporator is expected to operate approximately 30 days per year and the ETF is expected to operate 85 percent of the time). These conservative assumptions result in an overstatement of risk to the public.

**Worker Risk Evaluation** – Worker risk was based on exposure for 167 hours per year for the Evaporator and 1700 hours per year for the ETF for twenty years. Base on air dispersion modeling and prevailing wind direction, it is not possible for a worker to be exposed to highest average concentration of PCBs from both facilities simultaneously. This conservative assumption results in an overstatement of risk to the worker.

**Ecological Risk Evaluation** – As stated in Section 3.1.2 of the Application, the evaluation of ecological risk was determined by adopting the approach and assumptions used for assessment of ecological risk in the *Double-Shell Tank System PCB Risk Assessment* (CHG 2001a). A conversion factor was used to adjust for differences in operational times at LWPF as compared to DST operational times. The model for the DST ecological risk evaluation overstates the ecological risk for LWPF because of site-specific conditions (stack height, stack velocity, stack temperature, etc.), which provide better dispersion than the DST emission points. This *Double-Shell Tank System PCB Risk Assessment* was based on a number of conservative assumptions that are explained in Section 5.4 (Uncertainty Analysis) of that document. The same conservative assumptions apply to the risk evaluation for ecological receptors from operation of the LWPF. These assumptions, from CHG 2001a, are as follows:

- a. **Nonspecific Aroclor Data.** Because of the lack of information about the specific composition of PCB releases from the DSTs, if multiple values were available, the TRVs from the most toxic Aroclor mixture were used in this assessment. More information regarding the types of PCBs in the DSTs could result in lower emission rates and higher TRVs; use of these values could reduce HQs by as much as one to three orders of magnitude because of a one-to-two order-of-magnitude difference in release rates for different congeners, and a one-order-of-magnitude difference in toxicity factors.

- b. **Simplistic Land Deposition Model.** The simple deposition model used for PCBs on land is more appropriate for PCBs associated with particulates, while the emissions are almost completely vapor phase (because of the HEPA filters on the ventilation systems). This model most likely overestimates the amount of PCBs (and hence risk) found in the outer perimeter of the 20 km site radius, and may underestimate the exposure (and hence risk) to ecological receptors restricted to areas close to the LWPF. Plant species and wildlife with small home ranges would be most likely to be affected by this element of uncertainty.
- c. **Simplistic Water Deposition Model.** The use of the 7Q10 low-flow water data coupled with maximum 1-hour concentrations indicates that the water concentration modeled for the Columbia River most likely is overestimated in this evaluation.
- d. **Plant Uptake Transfer Factors.** The use of the simple deposition model assumes that all the PCBs emitted are deposited on soil. However, the air-to-plant transfer factor uses an air concentration of PCBs to calculate part of the tissue concentration in plants on the Site. If some of the PCBs emitted are assumed to be deposited on or taken up by plants, those PCBs should not be available for deposition on soil. Thus, the concentration of PCBs in plant tissue used in this evaluation is overestimated.
- e. **Average Daily Dose Calculation.** The calculation of daily dose did not consider the potential uptake from dermal exposure to animals or plants. This exposure route is considered quantitatively insignificant and likely immeasurable, but counters measures of conservatism already discussed.
- f. **Maximum 1-Hour Air Concentrations.** The use of maximum 1-hour air concentrations in the exposure calculations results in overestimation of the HQs in this evaluation. Because the effects endpoints that were assessed generally are more chronic or long-term in nature, the use of an annual average concentration would result in more realistic HQs.
- g. **Toxicity Reference Values.** This evaluation has used the screening-level TRVs, as recommended by the EPA, even when species-specific values that are relevant to the Site were available (see Tables 3-6, 3-7, and 3-8 in the Application). In general, the species-specific values should be emphasized, but both have been included to be consistent with EPA guidance.